BOEING
COMPUTER SERVICES

Guide to Operations

MAINSTREAM® Distributed Services Reference Library

AutoBOAT
Hull Design Module

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HARDWARE BLOCK INSTALLATION AND OPERATION

When installing your Hardware Lock, the COMPUTER end should be attached to your computer's serial port connector. Any peripheral device (such as a printer, plotter, digitizer or modem) that you wish to connect to the computer's ser should instead be connected to the end of the Hardware Lock for PERIPHERAL.

For almost all computers, you should attach the Hardware Lock directly to the connector of the computer with no intervening cable or adapter. The IBM AT (and its clones) is an exception in that the Hardware Lock should instead be connected to a standard IBM (9 pin to 25 pin) AT Communications Cable. Some clones may also have the wrong gender connector at the back of the computer. In such a case, you need a "gender changer" available from your computer distributor. It is also possible to connect a "straight-through" full 25-pin cable between your computer and the Hardware if it is required for physical flexibility.

For computers with more than one serial communications port, connect the Hardware Lock to the lowest numbered or lettered communications port supported on the machine. If your machine happens to have only a COM2 (or higher numbered) port, you will have to modify the jumpers or switches on the port to change it to COM1:,

You will still be able to execute AutoSHIP/YACHT as a demo version without the Hardware Lock. However, when saving or plotting with the block, the screen will display the following prompt:

```
*** HARDWARE PROTECTION DEVICE NOT FOUND ***
If this is not a demo version, install hardware block on COM (1)
and try again.  Demo versions do not use this feature.
PRESS ENTER TO CONTINUE.
```

Should a Hardware Lock be disconnected, removed or fail in service, AutoSHIP/YACHT will be unable to plot or save.

After ensuring that the hardware lock is properly installed, operations should resume normally. Normal operation is indicated by the fault message not repeating. Continue with your AutoSHIP/YACHT session, answering any prompt that may be outstanding when the Hardware Lock error occurred. If the fault message is repeated, you may need to replace your Hardware Lock. (Contact us for a replacement).

NOTE:
If you have an IBM PC/AT, you will either have to buy a standard IBM 9-pin to 25-pin cable to connect your existing 25-pin cable to the PC/AT serial port, or make your own 9-pin to 25-pin cable. If you wish to make your own 9-pin to 25-pin cable, use the 25-pin wiring diagrams below as a model. The pin number mapping is as follows:

AT 9-pin serial port Standard RS-232
1 --- CARRIER DETECT----------------8
2 --- RECEIVE DATA------------------3
3 ---TRANSMIT DATA ---------------- 2
4 ---DTR -------------------------------20
5 ---GNRD ----------------------------- 7
6---DSR ---------------------------------6
7---RTS----------------------------------4
8---CTS----------------------------------5
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CHAPTER I
SYSTEM INTRODUCTION

1.1 OVERVIEW OF SYSTEM CAPABILITIES

The hull design module performs all the tedious functions that are found in the conventional, manual lines fairing process of the naval architect or designer. This flexible program allows you to define a complete hull form with a remarkable economy of information, to control and manipulate the shape with great flexibility while maintaining a high degree of longtitudinal fairness.

Using the hull design module, one can build a surface in 3-D by designing a set of master curves (such as stem profile, a few sections and a transom outline). The program forms a complete, smooth surface by springing an infinite set of mathematically perfect "battens" or "ribbands" over these "molds". When you change master curves (by moving control points) the surface responds in a smooth, predictable way, retaining its longitudinal fairness as it adapts to your modifications. A new hull can be created in minutes or hours, instead of weeks of drafting. The resulting surface definition is so fair and complete that full-scale lofting of any longitudinal lines is unnecessary.

AutoBoat, AutoYacht And AutoShip
Three different hull design modules are available, AutoBoat, AutoYacht and AutoShip:

AutoBoat offers the same basic hull design and fairing functions as AutoYacht and AutoShip but lacks a number of advanced features. This program is intended for the student, hobbyist, amateur designer or the small craft designer who designs only a few boats per year and can do without some of the more powerful features of AutoYacht or AutoShip. AutoBoat has limited graphics, no digitizer or plotter support. AutoBoat requires a CAD program for output to printer or pen plotter.

AutoYacht is aimed towards the commercial designer. Several significant features are introduced in this module to increase productivity and efficiency in the design office. Some of these features are the ability to reduce hull thickness normal to surface, support for single or dual screen and high resolution graphics, digitizer input of master curves, hidden line removal, and the ability to draw "cutline" for broken sheer. Perspective views are produced on screen or paper and direct plotter output is possible.

AutoSHIP is the deluxe system aimed towards the Ship Architect who needs all the competitive edge technology can offer. Some significant features available only in AutoSHIP is Hull Shading, Display of Surface Curvatures, a BHS Section editor allowing output of a BHS file for working with AutoGHS, a sophisticated ship hydrostatics program for complex and exotic calculations. AutoShip Generation Four is designed to utilize the power in computing speed and memory of the AT's and 386's machines. AutoShip provides greater flexibility, adaptability and convenience to the user. Master curves can have more vertices, permitting more complicated shapes or closer matching to predefined curves. More master curves are permitted, and these are not limited to being in parallel transverse planes. For example, the fairbody profile or ghost line can be used as a master curve, designed at the outset and held fixed throughout the design procedure.

For a more detailed list of differences between these three modules, please see checklist of features available on the following page.

Checklist of features available	Auto-BOAT	Auto-YACHT	Auto-SHIP
Stands alone	yes	yes	yes
Full colour on screen	yes	yes	yes
Works in meters or feet	yes	yes	yes
Offsets in feet-inches-eighths or decimal	yes	yes	yes
Display 3 views simultaneously	yes	yes	yes
Zoom and pan	yes	yes	yes
Reduce hull thickness normal to surface	NO	yes	yes
Instant "flip" between longitudinals & sections while editing	yes	yes	yes
Calculate Cp, Cb, Cnp. LCF, LCB, GM, PPI, MTT, BWL	yes	yes	yes
Graphic Display of Curvatures	yes	yes	yes
Display Surface Curvatures	NO	NO	yes
Maximum number of master curves	8	12	12
Automatic vertex insertion	yes	yes	yes
Maximum number of stations	~~20~~ 60	~~30~~ 120	~~30~~ 120
Maximum offsets per station	~~yes~~ 60	~~yes~~ 100	~~yes~~ 100
Quick preview ~~at stations~~ IN EDIT MODE	~~40~~ yes	~~120~~ yes	~~120~~ yes
Display 1/2 angle of entrance	~~60~~ NO	~~100~~ yes	~~100~~ yes
Display deadrise angle	yes	yes	yes
Display section areas	yes	yes	yes
Display curve of areas on screen	yes	yes	yes
Input "target" section area curve	~~yes~~ NO	~~NO~~ yes	yes
Hidden line removal	NO	yes	yes
Shade hull	NO	NO	yes
Output to CADkey, VersaCAD, other major CAD programs	NO	yes	yes
Output AutoCAD, Generic CAD DXF Files	yes	yes	yes
Output .DRA , .PNL, .OFE files	NO	yes	yes
Output BHS files	NO	NO	yes
Draw "Cutline" for broken sheer, etc.	NO	yes	yes
Clip lines at transom	yes	yes	yes
Unlimited number of buttocks and waterlines	yes	yes	yes
Support dual or single screen	NO	yes	yes
Plotter support DMPL-HPGL-CALCOMP	NO	yes	yes
Support Hercules, EGA, CGA, VGA graphics	yes	yes	yes
High resolution graphics	NO	yes	yes
Support major brand digitizers	NO	yes	yes
Bow rounding	NO	yes	yes
Stern rounding	NO	yes	yes
Surface normal curvature	yes	yes	yes
Gaussian curvature	NO	yes	yes

Some significant features of these **hull design modules** are:

* By entering master curves from the keyboard or from a digitizing pad, the hull design program can produce profile, plan and body views of the hull on screen or plotter. *(Digitizer support is available only in AutoYacht and AutoShip)*
* Reduce hull by skin thickness perpendicular to surface. *(Auto-Yacht and AutoShip)*
* Produce offsets in feet, inches, eighths or decimal.
* Work in meters or feet.
* Calculate Cp, Cb, Cwp, LCF, LCB, GM, PPI, MTT, BWL and many more hydrostatic parameters
* Display curve of areas on screen
* Graphic display of curvatures to determine hull fairness.
* Automatic master curve insertion
* Automatic vertex insertion
* Lines clipped to cylindrical transom
* Any selection of buttocks and waterlines.
* Bow and stern rounding allows the program to handle vessels with radius or parabolic bows and canoe or tugboat sterns, in an easy and straightforward way. *(AutoYacht and AutoShip)*
* Attach PNL files. Examples of attached PNL files might include attaching the hull of a vessel to the rep of a keel you are designing for that vessel, or attaching keel and rudder drawings to a sailboat hull. *(AutoShip and AutoYacht)*
* Remove hidden lines from bow or stern body views.
* Develop cylindrical transoms at any angle.

Auto3D Module

(Included with AutoYACHT and AutoSHIP)

*Produce on screen 3D perspective views of the hull with rapid, tilt, rotate, zoom and pan.

* Produce isometric and orthographic views.

* Can draw full size patterns on Houston Instruments, Mutoh or Calcomp plotters.

* Output to various CAD programs including AutoCAD Release 10, VersaCAD, CADkey, Computervision, Generic CAD, ProDesign etc.

GHS YACHT

* Generate complete Stability reports
* With arbitrary heel, trim, sinkage
* With free trim
* Righting arm curves
* Cross curves
* Output on quality dot matrix printers (24 pin recommended).
* Loading conditions

OFED (Offset File Editor) Module

* Produces or edits .OFE files for use by Hydrostatics and Peformance prediction programs.
* Joins separately designed appendages to hull.
* Input from digitizer, keyboard, or AutoSHIP/AutoYACHT.
* Editing is accomplished on screen with interactive graphics display including rotation.
* Output to OFE, BHS, and DRA file formats.

(Compatible with Superfoil)

Weight Editor

The Coastdesign Weight Editor is designed to allow easy input, calculation and filing of parts lists and bill of materials together with their respective weights and centers of gravity.

LCG stands for Longitudinal Center of Gravity.
TCG stands for Transverse Center of Gravity.
VCG stands for Vertical Center of Gravity.
Units of length, breadth, and height are in feet or meters.
Weights are in pounds or kilos.

The default units setting is the same as your main configuration.

Parts are subdivided into Groups and items within a group. The program can handle up to 75 groups with up to 200 items in each group for a total of 15000 items. Sub totals for each group are provided as well as the total weight and center of gravity. The user interface is the new pull down/pop up style as used in all Generation Four products.

Item lists may be edited in spreadsheet fashion, by scrolling up and down with the arrow keys, and inserting and deleting items with the INS and DEL keys. Groups(of items) may be inserted or deleted in similar fashion, except that a warning is issued if an attempt is made to delete a group containing items.

Printouts of individual groups may be made from within the editing mode. The complete file may be printed or output to an ASCII disk file with the extension .TXT. The format is a neatly labelled report, suitable for presentation.

File Structure
Weight Edit files have the extension .WED. The are binary random access files, not readable by text processors. Because of the file structure, the size of the file is determined by the number of groups, approximately 40K per group. The number of items within a group does not affect file size.

FILES
Load
Reads an existing file from disk. You will be prompted for drive or directory to search (the last one used will be the default). Then a list of available files will appear. Highlight the file you wish to load with the arrow keys and the press <ENTER> to load the file. When you load an existing file, a copy of that file is made in the temporary file drive or directory, which for optimum speed should be a ramdisk. All editing affects only this file until you do a Save. When the file is read, the title screen appears and may be edited, particularly the date if you are updating the file. <Esc> returns you to the main menu. Select Edit/Edit items to view and edit the contents of the file. The current file name is displayed at the top of the screen.

FILES
New
Creates a new file. You will be prompted for a file name and directory. If the file already exists, you will be asked if you wish to to replace it. Then the title screen appears and may be edited. When completed, <Esc> returns you to the main menu. Select Edit/*Display Edit* to view and edit the contents of the file. The current file name is displayed at the top of the screen.

FILES
Save
Saves the edited file under the current name. No prompts.

NACAFIN Module*(AutoYACHT WORKS)*

* Designs NACA foil section keels and rudder.
* Allows leading and trailing edge rake, different chord ratios top and bottom, ballast calculations for inside or outside ballast, at full or partial depth.
* Calculates vertical and longitudinal C.G.
* Allows ballast to be limited to 30-90% of tip chord if desired.
* Can produce offsets or drawing file for Auto3D.

WED (Weight Editing Program) Module
(Works packages)

* Permits 3 dimensional entry of weights, groupings and neat printout. Generates VCG, TCG and LCG.

TOOLBOX of Programs
(AutoYACHT works packages)

* Offset (Feet-inches-Eighths) to decimal conversion
* Decimal to F-I-E Offset Table conversion
* Crown Deck Design
* Wheel Propeller Size Calculation
* Displacement hull speed
* Planing hull speed/power
* Rudder Shaft calculations
* Sail Plan calculations
* Mast and rigging calculations
* Displacement/Length/Sail Area Ratio

1.2 EQUIPMENT REQUIREMENTS

You will need the following items and equipment for operation of this program.

1.2.1 Hardware

Hardware is the term for the equipment constituting a computer system. To operate AutoSHIP/Auto-YACHT, you need the following hardware:

1. An IBM Personal Computer XT, AT, IBM PS-2 series or compatible with at least 640K random access memory (RAM). 80286 or 80386 machines are recommended for optimal performance.
2. Math co-processor *(Note: not required with AutoBoat)*
3. Hard disk with minimum of 2 MB of free space.
4. Monitor(B&W or color) matched to your graphics adaptor

Graphics adaptor: **one of**
IBM Color Graphics Adaptor (CGA),
NEC GBI or EVA 480,
Hercules Card, (See Note)
EGA or compatible boards
Sigma Color 400
Tecmar Graphics Master
CONOGRAPICS Model 40
AT&T or Olivetti indigenous graphics adaptor
AT&T or Olivetti Display Enhancement Board
Number Nine 2048 X 4 (and other NNIOS devices)
Mylex AGA 800 x 600
IBM PS-2 MCGA or VGA 640 x 480
WYSE WY-700 1280 x 800
Metheus Omega/PC 1024 x 768
Any other board that provides an AutoCAD(tm) version 2.1 ADI driver.

Hercules Note:
For machines with Hercules card or compatible, the file HGC.COM must be present in the root directory, and may be invoked by typing HGC FULL <enter>. It is a good idea to put this command in an AUTOEXEC.BAT file so that it will execute automatically on startup.Type:

COPY CON AUTOEXEC.BAT <enter>
HGC FULL <enter>
^Z <enter>

Note ^Z is produced by holding down the control keyand typing Z.

Note: AutoBoat only supports Hercules, EGA, CGA and VGA graphics.

5. RS-232 serial port (for plotter)
   2nd port desirable.
6. Parallel interface (for printer).
7. Plotter: (Optional)

Houston Instruments DMP series
Ioline(SeeNote).
HP-GL Devices such as Roland or HP Plotter.
Calcomp 1040 series plotter
Line printer (any type.) 24 pin Epson LQ, NEC P-series or Toshiba recommended.
Cables for the above.

Note: Although Ioline Plotters are advertised as Houston Instruments Compatible, Ioline Plotters apparently do not have the ability to do oversized plots that is available on Houston Instrument Plotters.

1.2.1 **Hardware** (continuation)

7. Plotter Cabling

You may not be able to purchase the correct cable for the RS-232 connection from the computer to the plotter. Radio Shack computer stores sell the necessary components. The program uses XON/XOFF handshaking and only a few wires are needed:

Computer   Plotter

Pin 1______Pin 1
Pin 2______Pin 3
Pin 3______Pin 2
Pin 4&5 jumpered
Pin 6&20 jumpered
Pin 7______Pin 7

This cabling applies to Houston Instruments, Hewlett-Packard and Calcomp plotters on the serial port. Roland plotters are usually configured on a parallel port. Roland Plotters must have the RDGL switch set to ON.

All instructions for operation apply to all MS-DOS and PC-DOS computers. The program is known to work on IBM compatible machines from AT&T, HP, Wyse, ARC, PC's Limited, Tandy, and many others, but we do not GUARANTEE correct operation with machines other than IBM and Compaq.

1.2.1 Hardware (continuation)

8. **COLOR**
All Coastdesign hull design modules **AutoBoat, AutoYacht and AutoShip** work in 16 colors on the IBM EGA color display, and other color displays. Stations are yellow, sheer, centerline and master curves are white,buttocks are Cyan and the Waterlines are red, with WL 0 in bright red.

9. **Digitizer**(optional):
Summagraphics, Calcomp, GTCO, Kurta, Hitachi, Houston Instrument Hi-pad, Tektronix or compatible. Please see appendix for configuring digitizer dip switches.
(Note: Digitizer input of master curves is not available in AutoBOAT.)

1.2.2 Software

Software is the term used for the diskettes used with your computer and the programs contained on them.

You will find some diskettes accompanying this manual. The diskettes that come with this manual should not be used in normal operation. Instead, copy them, then use the copies. Your data diskettes, may, and should be copied at regular intervals to protect against loss of data. See the DOS manual sections under COPY, DISKCOPY, BACKUP, and RESTORE.

1.2.3 Other Instruction Manuals

When you purchase your IBM or compatible personal computer, you will be supplied several instruction manuals. These will prove helpful in explaining questions you have concerning the equipment or its operation. You should familiarize yourself with the basic operations and features of your computer, as covered by IBM's "Guide to Operations." Many of the operations used in this system will be familiar.

1.3 USING THIS MANUAL

As we undergo constant revisions, enhancements and updates on our program, our manual is also under constant revision. There are times when changes made have not been documented in this manual. These undocumented revisions are contained in a file in your program diskettes called README.DOC. We suggest that you get a hard copy of this file by printing it out. To do this, simply go to your ASHIP or AYACHT directory and type:

PRINT README.DOC.

1.3.1 How this Manual works

This manual will show you the concept behind our hull definition program. You will learn gradually and practice what you learn as you work your way through the manual. When you finish, you can continue to use the manual for reference. The Table of Contents and the Index will help you find information quickly.

The manual is organized as follows:

Chapter I, 'Introduction' is a brief overview of system capabilities. It acquaints you with the equipment, program diskettes and supplies that are necessary for the proper utilization of the program.

Chapter 2 'Getting Started' takes you through the one-time operation you must perform with your system's diskettes before they can be activated. It also introduces you to frequently recurring operations such as the copying of system and data diskettes.

Chapter 3 'Concepts and Mathematics' provides an overview of the concept and mathematics involved in the use of this hull definition program and introduces you to some sample demo hulls that are used in the tutorials.

Chapter 4 is 'A guided tour' to orient the first-time user to the program.

1.3.1 How this Manual Works (continuation)
Chapter 5 'Program Operation' takes you through each menu and menu selections and describes the various functions of each selection.

Chapter 6 'Auto3D' describes the Auto3D orthographic and perspective drawing program and program operation. It also explains how one can draw full size patterns using Auto3D.

All other modules will have separate documentation with their own subject titles including:

OFED
WED
NACAFIN
TOOLBOX

CHAPTER I
SYSTEM INTRODUCTION

1.1 OVERVIEW OF SYSTEM CAPABILITIES

The hull design module performs all the tedious functions that are found in the conventional, manual lines fairing process of the naval architect or designer. This flexible program allows you to define a complete hull form with a remarkable economy of information, to control and manipulate the shape with great flexibility while maintaining a high degree of longtitudinal fairness.

Using the hull design module, one can build a surface in 3-D by designing a set of master curves (such as stem profile, a few sections and a transom outline). The program forms a complete, smooth surface by springing an infinite set of mathematically perfect "battens" or "ribbands" over these "molds". When you change master curves (by moving control points) the surface responds in a smooth, predictable way, retaining its longitudinal fairness as it adapts to your modifications. A new hull can be created in minutes or hours, instead of weeks of drafting. The resulting surface definition is so fair and complete that full-scale lofting of any longitudinal lines is unnecessary.

CHAPTER 2
GETTING STARTED

Backing up your program diskettes:
The first thing you should do when you have unwrapped your package is make a working copy of the AutoSHIP/AutoYACHT disks using the MS-DOS DISKCOPY utility. Put the original disk in a safe place and use the copy from now on. If the copy is ever damaged or destroyed, you can make new copies from the original disk. IBM DOS includes two different commands for creating back-ups; DISKCOPY and COPY.

The DISKCOPY command is used to copy an entire diskette to another. DISKCOPY copies every file on the diskette including DOS in one operation. DISKCOPY is the fastest method of copying a diskette. Refer to your DOS manual.

DISKCOPY with 1 Drive
If your system contains only one diskette drive, you will have to remove the original diskette and replace it with the diskette on which the copy is to be made. This process is known as **swapping.**

To begin DISKCOPY, insert the program diskette into Drive A, then from the A prompt, type:

DISKCOPY A: A:

DOS will prompt you as follows when it is necessary to swap diskettes.

```
Insert source diskette in Drive A:
Insert target diskette in Drive A:
```

The source diskette is the original diskette, the target diskette is the back-up.

When the disk swapping process has been completed, the following message will appear:

```
Copy complete
Copy another (Y/N)?
```

If N is entered, DISKCOPY will end and the DOS prompt will appear.

DISKCOPY with 2 Drives
Backing up diskettes is much easier if your system has two drives, as swapping will not be necessary.

To begin DISKCOPY, enter the following from the A prompt:

DISKCOPY A: B:

You will be prompted:

Insert source diskette to Drive A:
Insert target diskette to Drive B:
Strike any key when ready.

Insert the diskette to be copied in drive A and the back-up diskette in drive B, and press any key. The following message will be displayed during the copying process.

```
Copying 9 sectors per track, 1 side(s)
Formatting while copying
```

Once the copying process has been completed, the following prompt will appear:

```
Copy complete
Copy another (Y/N)?
```

2.1 INSTALLATION ON THE HARD DISK

All AutoSHIP/YACHT/BOAT programs are designed to run on hard disks, either the IBM XT, AT, PS Series or compatibles using DOS 3.2 or any version after 2.0.

You should familiarize yourself with operation of the hard disk and the related DOS functions before continuing. Before you proceed with the installation of your programs, first read the appropriate sections in your IBM DOS manual.

IBM HARD DISK SYSTEM
Users of the IBM Hard disk may be installing a number of different programs on the hard disk. Please note that AutoSHIP/YACHT/BOAT require a minimum of 540 K free space in your RAM. If you run CHKDISK in your machine and find less than 540K free, remove memory resident programs from your AUTOEXEC.BAT file.

TO INSTALL:
NOTE: All characters including spaces and punctuation are significant. Type carefully.

Place program diskette 1 in drive A and:
At the C> prompt, root directory type:
A:Install

the Install command will automatically create a directory called GEN 4 and install all of the required files in that directory.

Continue copying all the supplied diskettes until all files and programs will be copied on to the hard disk. Place the supplied diskettes in a safe place.

Reboot the system (Cntrl-Alt-Delete)
Change directory by typing from the root directory:

CD \Gen4

from the Gen4 directory prompt type:
AMENU
and you will be presented the Coastdesign program manager.

2.2 Coastdesign Program Manager

The Program Manager allows you to run the various programs that are in this directory, set directory for files, configure your hardware and exit to DOS.

It consists of four Main menu: RUN, DIRECTORY, CONFIGURE and EXIT.

RUN

AutoShip	Hull Design & Fairing
Auto3D	Orthographic & Perspective Display
SEC	GHS Section Editor
OFED	Offset Editor
BHS	Stability Calculations
WEIGHT EDITOR - Weight and CG calculations	

The above menu is a standard AutoSHIP menu. Auto-Yacht and AutoBoat have different menus.

This menu can be edited to include other programs you may have in the same directory or programs available through the DOS PATH command.

2.2 Coastdesign Program Manager

Editing the RUN Menu

There is a file called the MENU.LST. This file contains the data that appears on the RUN menu. If you have other programs that you wish to appear on the menu, you can go to the Directory prompt by exiting to Dos and edit this file.

The purpose of the RUN menu is to save you from memorizing all the executable names needed to run the various modules included in your program. Executable name refers to the name you type to make the program run. Here in the RUN menu, you simply make your selection by hitting the udlr (up, down, left, right) key.

The file **MENU.LST** has the following structure:
The first line refers to the executable name.
The second line refers to the name that appears on the menu.
The third line is a short description for the program.

For example: The **MENU.LST** will show the following lines for Auto3D.

Aplot
Auto3D
Orthographic and Perspective Display/Plotting

2.2 Coastdesign Program Manager

Editing the RUN menu

If you wish to add a program called ABS, you can edit this menu.lst file by first typing: (To do this, you need to have a word processor or editing program such as PC write)

The file name is **MENU.LST** and it is an **ASCII** file editable with most word processing programs. There are three lines for each menu entry:

EXAMPLE	*(comments in brackets)*
ABS.EXE	*(executable name)*
ABS	*(displayed name)*
ABS rule for offshore racers	*(description)*

2.3 General Operating Conventions

1. The first time you run the program you must configure immediately by going to the configuration menu.

2. The program provides default responses to most input prompts; i.e. if you simply press <ENTER> without keying in any other entry, the program will assume a certain entry. The entry that will be taken is generally indicated on the screen as follows:

If the prompt calls for a numeric entry, the default value will often be displayed in parentheses. Typing<ENTER> will leave this value unchanged. Where there is no value in parentheses typing <ENTER> will make the value zero.

For example:

```
No. of master curves to enter [3]
```

Note that the number 3 in bracket, which is the default value. This means that if you just hit the carriage return (enter) key, the program will assume that you are accepting the value as indicated in the bracket. If you wish to change the value simply type in the new value and hit <ENTER>.

If the prompt calls for YES/NO entries, a default will be displayed in parentheses, this answer may be toggled with the space bar, or it will respond to the first letter of the word e.g. Y for Yes, N for no.

```
[NO] Digitize input Y/N
```

Simply hitting the enter key will accept no (the default) as the answer.

3. In some areas of the program waits have been provided to prevent information from scrolling off the screen. Pressing <ENTER> will cause the program to proceed.

4. Most calculations or plot requiring more than a few seconds can be aborted by pressing the escape key. This is to avoid waiting for a lengthy series of calculations to be completed when you realize you have made an error in setting up the job. Termination may take a few seconds so have patience!

2.4 Running the Configuration Routine.

To access the Configuration Program go to:

CONFIGURE

You will be prompted to configure:

Hardware

The configuration menu will appear.

EXIT
RE-CONFIGURE GRAPHICS BOARD
RE-CONFIGURE PLOTTING DEVICE
RE-CONFIGURE PLOTTER
PLOTTER CALIBRATION
PLOTTER DELAY
CAD EXCHANGE FORMAT
FEET/METERS

Use the up-down arrow keys or the first letter of the menu item to make your selection, then press <ENTER>.

2.4.1 Configuring your Graphics Board

Your graphics board determines the resolution of the lines that you see on the screen. In a graphics display, the picture is formed by turning on specific dots ("pix-els") which are in fixed positions on the screen. The higher the resolution, the more dots there are. For example: A graphics board with a resolution of 640 x 200 - means 640 dots horizontally and 200 up and down. A line is displayed by turning on the set of dots that best approximates the desired line, within the screen's set of available dots. Especially when a line is almost horizontal (like the sheer line in profile) or vertical, you can see it jumping from one row of dots to the next. This is called "jagging" and is a limitation of the graphics board. Inside the computer, the sheer line is far smoother than what you see on the screen.

To configure to your specific Graphics Adaptor, select Re-configure Graphics Board

you will be prompted:

[YES] Is this a monochrome monitor?

If your answer is yes, you will be asked to the config-ure for your graphics board.

2.4.1 Configuring your Graphics Board

SIGMA COLOR 400
IBM COLOR GRAPHICS ADAPTOR
HERCULES MONOCHROME ADAPTOR
EGA, NEC GENOA, AHEAD
TECMAR, TOSHIBA, COMPAQ
CONOGRAPHICS MODEL 40 OR 2000
MYLEX AGA 800 X 600
AT & T/ OLIVETTI INDIGINOUS GRAPHICS BOARD
NUMBER NINE REVOLUTION 2048 X 4,
1280 X 960 NON-INTERLACED
AT & T OLIVETTI D.E. B. 16 COLOR
WYSE WY-700 1280 X 800
METHEUS OMEGA/ PC 1024 X 768
AUTOCAD ADI (tm) DRIVER single screen
AUTOCAD ADI (tm) DRIVER dual screen

2.4.1 Configuring your Graphics Board

EGA Board Configuration

you will be prompted to select the specific EGA mode as follow:

```
RESTART CONFIGURATION
640 x 350  16 colors
NEC GPI EVA 480, 640 X 480
VIDEO 7 VEGA deluxe 640 x 480
EGA 640 x 350 Monochrome (see note )
GENOA SUPER EGA 800 X 600
AHEAD SYSTEMS EGA 2001
AHEAD WIZARD 800 X 600
ATI WONDER 800 X 560
SIGMA EGA 480
```

Note: If you are using an EGA board with a monochrome monitor that is Hercules compatible, then configure it as a Hercules Card, and set switches accordingly on the EGA board for the Hercules mode. Consult your graphics board's owner's manual for more detailed instructions. For Hercules Board's user, please see note on Hercules on Chapter 1.

2.4. 1.1 ADI Driver
Using AutoSHIP/AutoYACHT with AutoCAD ADI 2.1 Driver.

The ADI Driver 2.1 is supplied by the individual graphics board manufacturer. If your graphics board is not listed in the configuration menu then contact the manufacturer of the graphics board for a copy of their ADI Driver. Virtually all graphics boards on the market are supported by this device. Configure the drivers according to the manufacturer's instructions. Place the name in the AutoEXEC Batch File so the drivers will run each time the configuration is started.

The ADI Driver has been tested on the following devices and found to function correctly:
AristoCAD Kicker Card (Single screen)
Cambridge Accelerator Board (dual screen)
Galaxy Board
No. 9 Pepper Pro 1280 (Dual screen)
VMI Vermont Microsystems 1024
Moniterm Viking Color or Monochrome

Most other ADI drivers should work without problems. But please let us know if you have difficulties with a detailed description of your symptoms. Some drivers seem to work best when configured for single screen and others work better in dual screen mode. Try both configurations before concluding you have a problem. *(Note: ADI driver support is only available in Auto-Ship and AutoYacht)*

2.4.2 CONFIGURING FOR DIGITIZER.

Proceed to configure the digitizer, by selecting the specific pointing device:

```
NONE
GTCO 7 SERIES OR BITPAD COMPATIBLE
HITACHI HDG 1111
SUMMAGRAPHICS MM SERIES
GTCO 5 SERIES
TEKTRONIX 4957
HOUSTON INST. HI-PAD
CALCOMP DWG  BD/ OTHER MM COMPATIBLES
ADI (TM) POINTING DEVICE
```

The digitizer is expected to be on Com Port 1, and must be ready and on line for configuration to proceed. Otherwise,the computer may hang.

If your machine has only 1 serial port, you will have to select Port 1 for both the digitizer and plotter. This will require swapping cables each time you wish to change devices. Choose the driver appropriate to the digitizer you have installed. See appendix A.

Note for Summagraphics Digitizers:
Some Summagraphics MM Digitizers do not work when configured as Summagraphics MM Series. In this instance, configure as Calcomp/MM Compatible.

2.4.2 Configuring for Digitizer

After making a selection, you will be prompted:

Digitizer/Mouse goes on Communications Port 1. To Configure Digitizer must be ready and on-line. <Enter> to continue.

Digitize lower left corner of screen pointing device Digitize upper right corner of screen pointing device

Point pen on area of tablet that you want to use. Usually a size smaller than the tablet, about half size.

Note: It has been reported that the digitizer sometimes behaves erratically when using a high speed 12 Mhz machine. This is because the message the computer is sending to the digitizer is too fast for the digitizer to comprehend, thereby causing erratic behaviour. Sometimes the solution to this is to slow the computer clock speed down to about 8 Mhz.

Also please see the Appendix for specific instructions for Summagraphics digitizers.

2.4.3 Configuring your Printer Plotter

None
Ansi
Epson 8 Pin and Compatible
Epson RX and Compatible
Epson LQ and NEC 24 pin
NEC 8 pin
Okidata Microline 192/193
Toshiba P341
Panasonic KX-1092
HP Think Jet Printer
HP Laser Jet
Postscript file (Laser.prn)

Note: Only AutoPlane currently supports a printer plotter. This configuration is provided for future use.

2.4.3.1 Configuring your Plotter Port

```
NO PLOTTER
SERIAL COM1:
SERIAL COM2:
PARALLEL LPT1:
PARALLEL LPT2:
DISK FILE PLOT.PLT
```

If you're also using AutoCAD you should know that AutoCAD expects the digitizer to be on Port 1 and allows you to configure the Plotter to Com 1 or 2. Of course if you have 2 serial ports and a digitizer, you should put the plotter on Com 2.

2.4.3.2 Configuring Your Pen Plotter

None
DMP-40, 42, 52, 56 or Ioline
H-P, Roland, OCI or Other HP-GL Device
Calcomp 1043 or Compatible
Mutoh Pencil Plotter

After configuring your plotter you will be prompted:

Plotter Baud rate (2400)?

If you're also using AutoCAD, you should know that AutoCAD expects Houston Instrument plotters to operate at 9600 Baud. However, the DMP 42 Plotter defaults to 2400 Baud on Power up. We find it convenient to configure it for 2400 Baud so we don't have to change the rate manually each time we use the plotter.

The DMP 52 Plotter has configurable defaults and we suggest you set it to 9600 Baud, so that it can be used with AutoYACHT/AutoSHIP and AutoCAD/VersaCAD without changing settings.

Note on Ioline Plotter: Although Ioline Plotters are advertised as Houston Instrument Compatible, Ioline plotters apparently do not have the ability to do oversized plots which is available in Houston Instrument Plotters. They are limited to 80 inches.

2.4.3.3 Plotter Delay

Set delays for Plotter handshake. You will be prompted:

```
Delay to use [0]
```

Sample delays:
IBM XT 0
IBM AT 600
Fast AT 900
386 1200
If delay is too long, plotting will be slow.
If delay is too short, stray lines will appear.

The numbers given on the screen are guidelines only. Delay can be set as low as 0. However, if you get stray lines on your drawings, you should adjust the delay until you get it right. The basic purpose of the delay is to keep the speed of the computer down so that the plotter can keep up with it.

2.4.3.4 Plotter Calibration

Plotter Calibration for accurate scaling.

Plotter Points per inch across (200)?

Plotter Points per inch down (200)?

The defaults set for calibration are the same as that of the plotter's manufacturers. The DMP Series Plotters are designed for 200 addressable points per inch. However, minor variations between plotters may require recalibration for best accuracy. Instructions for doing this are found in the Auto3D section. Normally, you should just accept the default and hit the enter key. However, if your plotter does not plot to the correct scale, you can recalibrate.

2.4.4 CAD Exchange Format

The following options appear on screen:

AutoCAD 2.1 (lines)
AutoCAD 2.5 - 9 2D polylines
AutoCAD 10 - 3D polylines
VersaCAD 5.0 TWG lines
Generic CADD 2.0 lines
ComputerVision MicroCADDS 3D
CADKey 3D.CDL file

2.4.5 Feet/Meter

[NO] Metric Measurements

Type in Y or N for metric measurements. This sets the the default for new boats. However, each file contains a "bit" which tells the program what units to use. This overrides the configuration.

KEEP NEW CONFIGURATION [YES]

If you hit <enter> at this prompt, the configuration will be saved and these defaults will be used until the next time you run the Configuration Program.

If you reply N then the Configuration Program will exit without changing the configuration file aplot.con.

2.5 File Organization

2.5.1 Naming your File.

File names have the general form:

name. extension

where the extension is used as a file type identifier.When AutoSHIP/YACHT asks for a file name, you should enter just the name, without the period or extension, unless stated otherwise in a particular command description.AutoSHIP/YACHT adds the appropriate extension for the task at hand. AutoSHIP/YACHT restricts the characters permitted in its file name to letters, digits, and the special characters "$" (dollar), "-" (hyphen), and "_"(underscore). You can have up to a maximum of 8 characters in a name.

The following names are valid:

FERRY48
NEWBARGE

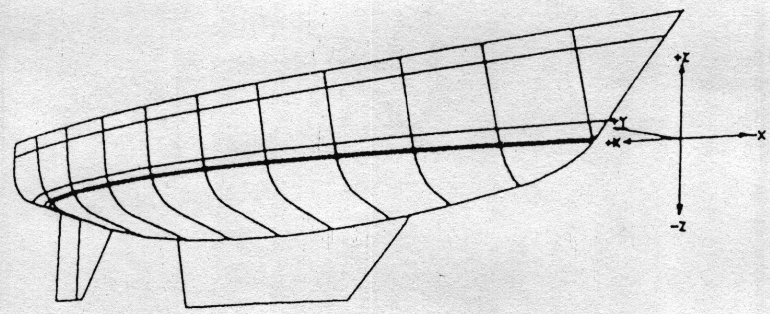
The following names are invalid:

50%TUG (percentage is an invalid sign)
HULL12.3 (decimal is an invalid sign)
"SJ123" ("" is an invalid sign)

The extension of the filename tells its purpose i.e.

- .REP is a AutoBOAT/YACHT/SHIP hull repre sentation.
- .OFE is an offset file for use by INSTAB
- .DRA is a draw file for use by Auto3D
- .WSE is a weight schedule file.
- .DXF is a drawing exchange file to be read by AutoCAD or similar CAD prog.

IMPORTANT CONVENTION USED



XYZ COORDINATE SYSTEM

All programs in AutoBOAT/YACHT/SHIP series use the same coordinate system to describe a 3 dimensional hull in space. The above illustration shows the system in graphic form.

X always represents longitudinal dimensions
Y represents lateral dimensions
Z vertical dimensions

Our convention at Coastdesign is to
let X=0 represent the forward perpendicular, and
Z=0 the design water line.
Then Z is negative for all underwater parts of the vessel.

Jensen Maritime uses a convention which locates X=0 at Station 5 therefore the forward portion of the vessel is always in -X.

They also locate Z=0 at a baseline below the hull so all Z values are positive.

Values for X,Y and Z are in feet (and decimal fractions) or meters -- whichever you prefer.

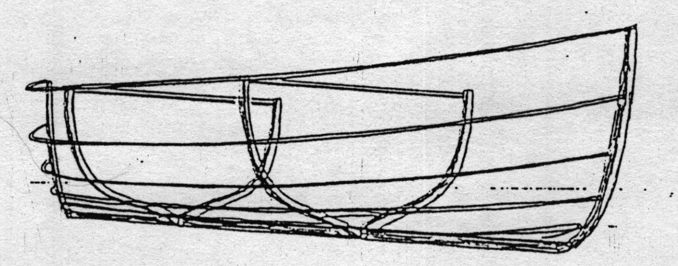
In our office we use both, depending on the clients requirements. If you plan on using the metric system regularly reply "Y" to "metric input" at the configuration menu.

CHAPTER 3

AutoSHIP/YACHT CONCEPTS AND MATHEMATICS

3.1 AutoSHIP/YACHT/BOAT HULL DEFINITION

Creation of a hull surface in AutoSHIP/YACHT/BOAT resembles an ancient form of boatbuilding called "master-frame-and-batten", practiced by builders of traditional working craft and still found in use today.The main advantage to the builder is that it dispenses with all need for lofting, offsets, lines, or any paper plans at all. Vessels up to 100 feet or more in length are regularly built by this method in the Eastern Mediterranean without benefit of any plans or specifications except length, beam, and estimated displacement. The Auto-SHIP/YACHT/BOAT program is a mathematical model based on the same master-frame- and -batten method.



The essential procedure of the master-frame-and-batten system is as follows:

1. The keel, stem and horn timbers are shaped by hand and eye to provide the desired profile. The transom may be set up on the horn timber.

2. One, two, or three master frames are shaped by eye and attached to the keel. These are transverse structural frames. Because they are far apart, they can be shaped-almost independently of each other, by the builders eye.

3. A series of full length battens are sprung around the frames and attached to the stem and horn or transom. This step provides the essential definition of a surface in 3-dimensional space. The individual, physical battens can be thought of as a series of positions for a single batten which is moved incrementally down the side of the hull, in contact with the master frames, stem, and horn timber or transom at all times. In its motion it sweeps out the hull surface.

4. Templates or jigs are used to pick up hull "offsets"from the battens at any transverse station where a structural frame is needed. These frames are then shaped to fit to the battens exactly.

5. The battens are removed, frames are positioned and attached to the keel, and the hull is planked.

3.2 MASTER FRAME AND BATTEN METHOD ANALOGY WITH AutoSHIP/YACHT/BOAT

In defining a hull with AutoSHIP/YACHT/BOAT we follow a very similar procedure. In place of the stem, master frames and horn timber we use a series of master curves in space, each defined by a very flexible mathematical spline which we control by manipulating the the space coordinates of a broken line which approximates the curve.

The program allows for as few as 3 or as many as 12(8 for AutoBOAT) master curves, but **if we want a truly fair hull to emerge automatically, we should hold the number of master curves to 3-5 in number.** The bow profile or rabbet line, two or three stations, and the transom or a station just beyond the transom, would be good choices. Additional master curves are sometimes useful on IOR boats or others which require deliberate distortions for some reason.

Now the master-frame-and batten builder has some discretion in how he arranges his battens. Although they cannot cross each other he can, for example, crowd them together more down toward the forefoot or up toward the stem as they run forward to join the stem timber, thereby controlling to some extent the fullness of the bow. In any case he needs a rule to go by; in practice he generally defaults to subdividing the arc lengths of his Master Curves into equal intervals. He would mark off the Master Curves with tick-marks and make the batten land on the same tick-mark on each Master Curve.

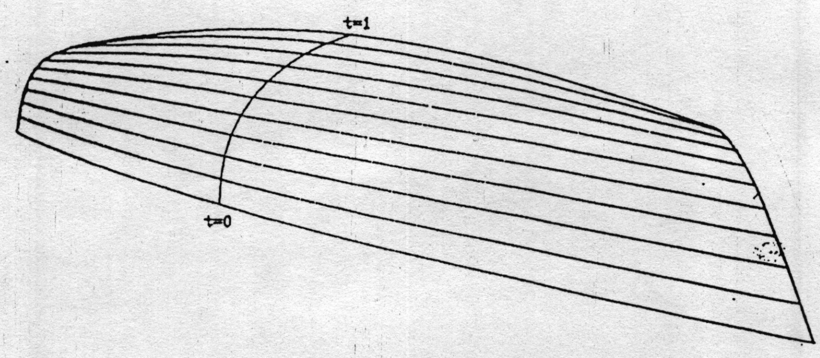
Our Master Curves have tick-marks on them already. Since they are parametric curves in space each one is represented by equations of the form

$$x = fx_1(t) \quad \text{— longitudinal coordinate}$$
$$y = fy_2(t) \quad \text{— transverse coordinate}$$
$$z = fz_3(t) \quad \text{— vertical coordinate}$$

t is the parameter, which runs from 0 to 1 along each-Master Curve. When **t = 0**, the equations yield the point$<fx_1(0), fy(0), fz_3(0)>$, the starting point of the Master Curve, which we normally take as a point on the sheerline. When **t = 1**, the equations yield $< fx_1(1), fy_2(1), fz_3(1) >$, the other end of the Master Curve, which can usually be taken on the centerline or rabbet. Since the functions fx_1, fy_2, fz_3 are continuous, varying t from 0 to 1 causes $< x, y, z>$ to sweep out a continuous curve in space, connecting these two end points; how we control its shape will be explained later. But think of each of the Master Curves as being marked off with **values of t running 0 to 1.**

In place of the builder's batten we use a mathematical model of it called a **cubic spline.** This curve behaves in a way that is very similar to the builder's batten or the draftsman's spline. You can think of a whole family of these splines, each one touching (with simple support) the place on each Master Curve where t has the same value —for example, t = 0, 0.1, 0.2, ... or 1.0. Or you can think of the hull surface being swept out by a single spline being moved down the side of the boat in contact with each Master Curve, with an apprentice at each Master Curve holding it on the right value of t as the master carpenter calls out the signals; "t = 0, ...

now, t =0.01, ... now, t= 0.02, ..." etc. There's an infinite number of positions for this spline, each labeled by a value of t between 0 and 1. See illustration below:



Master frames and battens

Hull surface formed with only 3 master curves, pictured as building templates erected upside down. The longitudinal splines join points having the same values of the parameter t, ranging from 0 at the sheer to 1 at the keel.

The parameter t will figure prominently in our discussion of AutoSHIP/AutoYACHT. The basic rule for locating a point < x,y,z> on the surface is as follows:

(1) Given **t**, run through all N Master Curves and calculate the point on each one having this value of t(i.e., evaluate fx_1, fy_2, and fz_3 for each Master Curve).

(2) Pass a cubic spline $y = s_2(x)$, $z = s_3(x)$ through the resulting N points.
(3) Intersect this spline with a transverse plane (i.e.,evaluate s_2 and s_3 for a particular value of x).

This provides a mathematical description of the surface in the form

$$x = f(x,t)$$
$$z = g(x,t).$$

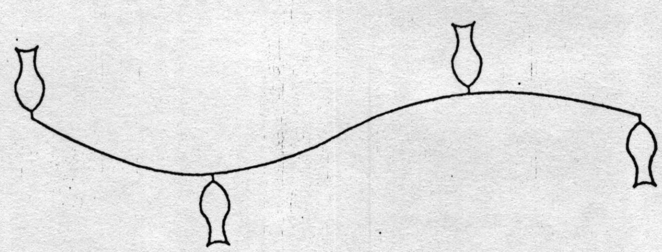
A station is generated by holding x constant and varying t from 0 to 1. A longitudinal is generated by holding t constant and varying x. If we wish to locate a point with a given z, for example where the waterline z = 0 crosses a station, we have to make a search holding x constant and varying t until we find the value of t that makes z zero.Then y calculated for this value of x and t will be the transverse offset. A computer can carry out these calculations very rapidly and accurately, quickly giving us back lots of information about the surface we have defined.

By now it's clear how a complete surface definition emerges from a few input curves. The simplicity of the building system which allows the traditional boatbuilder to create a fair hull from just the profile and a few stations has carried over to a simple mathematical system, built into a computer program, which allows the naval architect to define a complete hull form with a remarkable economy of information, to control and manipulate the shape with great flexibility while maintaining a high degree of longitudinal fairness. Now we will focus on the two essential curves that the system is built around, **B-Spline curves** for the Master Curves, and **cubic splines** for the longitudinals.

3.3 Spline Functions

First, what is a spline? Spline functions originated for curve fitting, as mathematical models of the draftsman's spline — a thin uniform beam which is simply supported at a number of points. See illustration below:

Cubic Spline Behavior (no end moments)



The cubic spline as a model for the drafting spline and weights (ducks)

3.4 Master curves in the Plane.

Behaviour of Quadratic(Order 2) B-splines for 3 through 30 control points(vertices).

(1) At values of t where the knots occur in the B-splines -- t=1/(n-2), 2/(N-2)... (N-3)/(N-2) -- the parametric quadratic B-spline (PQBS) curves passes through the mid-point of the line joining Vertices 2 and 3, 3 and 4,... N-2 and N-1, and it is tangent to this line. These midpoints are also the only points where there can be a disconitnuity, or change in sign, in the curvature of the PQBS curve.

(2) If three vertices lie on a straight line, a portion of the Master curve will be perfectly straight.

(3) If two vertices coincide, the master curve will pass through them, and the tangent as well as the curvature can be discontinuous at this point.

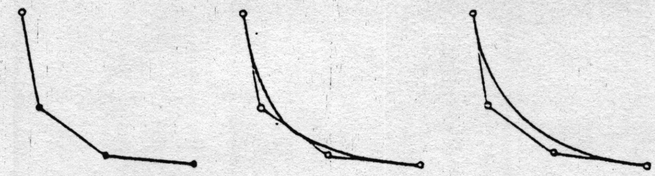
Between any two knots, the B-spline basis functions are simply quadratic functions of t, and therefore so are y and z.The entire shape of the Master curve is independent of the coordinate axis orientation, and depends only on the relative position of the vertices. If the vertices are moved or rotated while maintaining their relative positions, the master curve is transported with them without any alteration of form.

AutoSHIP/AutoYACHT/BOAT allows you to choose 3 different orders of B-spline curves when entering or editing a rep.

B-SPLINE ORDER=1 The master curve follows the vertices exactly. This order of B-spline is useful for designing hard chine hulls.

B-SPLINE ORDER=2 The master curve at the sheer line (t=0) and centerline (t=1) is tangent to a straight line between the first and second vertices and the last and second last vertices respectively. The other portions of the curve are tangent to the mid point between vertices. A hard corner may be formed by locating two vertices at the same point. A minimum of 3 vertices are required for Order 2 B-splines.

B-SPLINE ORDER=3 The master curve at the sheer line (t=0) and centerline (t=1) is tangent to a straight line between the first and second vertices and the last and second last vertices respectively. The rest of the curve is very smooth and continuous, following neither the tangents or vertices directly, but influenced by them. Third order B-splines are rarely used, and can be somewhat difficult to manipulate. B-spline order 2 is recommended for most round bilge hulls. Order 3 may be useful in the case of "Over control" or too many vertices. A MINIMUM OF 4 VERTICES ARE REQUIRED FOR ORDER 3 B-Splines.

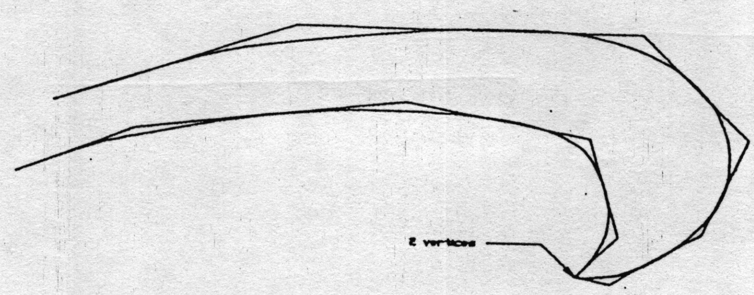


B-spline order 1 B-spline order 2 B-spline order 3
Master Curve Behavior

3.5 FITTING CURVES

Fitting an arbitrary curve in the plane with a master-curve is so far not completely systematized; however, we have a procedure which is quite successful. See illustration:

Fitting Vertices to an arbitrary curve



(1) The end vertices of course go at the end points of the target curve.

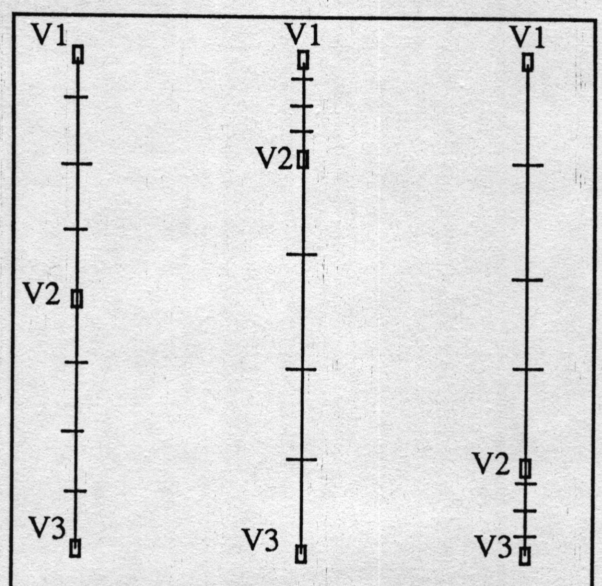
(2) If the target curve has a hard corner in it — dis-continuous tangent — two vertices have to go there. This corner effectively divides the curve fitting problem into two separate, essentially independent problems. In the following steps we assume corners have been eliminated by putting two vertices at each, so we are dealing with a target curve having continuous tangent.

(3) At each end of the target curve draw the tangent-line. If the curve has a point of inflection (reversal of curvature), a midpoint will have to go there, so draw the tangent line at this point too.

(4) Now slide one or two lines (use the edges of triangles) around on the paper, keeping them tangent to the target curve and seeking a position where the points of tangency are midway between intersections of these lines and the tangent lines already on the drawing. The intersections will be the vertices. If you can't do it with one line, try two; if you can't do it with two, try three. Given enough vertices, you can fit any curve to any degree of accuracy. If there is a part of the curve with small radius of curvature you will invariably find you need two vertices close together in that area; for zero radius these merge to form a sharp corner.

Normally we get the feeling that there's at least one degenerate degree of freedom in this fitting procedure.It seems you can slide each vertex in the same direction, parallel to the target curve, and find another fit that seems just about as good. This generally means there's a multiplicity of satisfactory fits. One effect of shifting the vertices this way is to shift the t values along the curve.

As an example of a situation where the degeneracy is particularly clear, consider the case where the target curve is a straight line. We could use any number of vertices, as long as they lie on the line, but let's do it with the minimum of three. The middle vertex V2 can lie anywhere on the line. If it coincides with V1, it drags the t values with it toward V1; if it coincides with V3 it drags the t values toward that end. If V2 is in the middle, t is uniformly distributed along the line. (If this line were the plumb stem of a YACHT hull we would clearly be influencing the fullness of the bow by shifting the battens up and down the stem as we varied V2).



3.6 MASTER CURVES

AutoSHIP/AutoYACHT allows 2to 12 Master curves. The only constraints on the master curves are:
(1) 2 to 30 Vertices per master curve.
(2) 2 master curves may not intersect.
(3) The master curves must be in order from bow to stern and must not cross over each other.

The more master Curves used and the closer they are spaced, the less automatic the longitudinal fairing will be. With 5 well spaced master curves you can do almost anything you want for sections and a fair surface comes out. There is not enough freedom for the surface to have lumps and bumps. But it is obvious that with 12 arbitrary master curves you are not necesssarily going to generate a fair surface. The greater power of 6-12 master curves is appropriate for fitting a surface that is already well faired (for instance, an existing faired lines plan) or for a hull of unusual complexity. In either case careful attention would have to be paid to fairness by checking ~~a good number~~ a good number of longitudinal intersections, and we would expect some minor adjustments of master curve vertices might be required to smooth out the lines. There is no general requirement that the master curves have the same number of vertices, but chine vessels need the same number of vertices in order for the number of chines to remain the same. **There is no doubt that it is easier to get a fair hull if the number of vertices is the same on all master curves and they are distributed similarly along the curve.**

3.7 CUBIC SPLINES IN THE PLANE

The longitudinal splines of the hull actually are two independent sets of equations, one in the XY plane and the other in the XZ plane. The combination of these two formulae is a 3 dimensional curve. We therefore can consider the two dimensional behavior of these splines as a guide to their 3 dimensional properties.

The cubic spline has a second derivative Y" (or Z") which represents the amount of curvature at any given point on the spline. If Y"=0 then there is no curvature and the spline at that point is a straight line. In the Display/Edit Menu selection of AutoSHIP/AutoYACHT there is a selection for Longitudinal. This allows you to display the knots (control points) at any master curve vertex and their second derivatives Y" and Z" in graphic form. Some characteristics of these numbers are:

(1) Y" is positive when curvature is concave relative to the center line and negative when curvature is convex relative to the centerline. Thus at the sheer line Y" is virtually always negative.

(2) Z" is positive when curvature is concave relative to the water line and negative when curvature is convex relative to the water line. Thus at the sheer line (normal sheer) Z" is virtually always positive.

(3) Whenever Y" crosses zero there will be an inflection point. This is a result of change of sign of Y".

(4) Maximum and minimum curvature can only occur at control points (Knots).

(5) Uniform curvature is indicated by constant Y". The curve in such a case is actually a parabolic arc.

(6) A fair curve is one in which the second derivative (Y"or Z") varies in reasonably linear fashion. Using only three master curves makes an unfair surface impossible,however it may not give the desired degree of shape control.

The ends of a draftsmans spline which are unsupported beyond the ends of the the curve being drawn naturally- have no end moment. The cubic spline behaves much like the draftsman's spline if Y" is specified as zero at both ends. The draftsman can either accept this condition or place a weight on the spline beyond the end of the curve and crank in more curvature. It can be argued that this is not a good idea since the boat builder has no comparable way of applying moments to the planking materials. Certainly the most easily built boats are those with zero end moments. Nevertheless AutoSHIP/ AutoYACHT/AutoBOAT provides two ways to apply end moments if so desired. They are often necessary on full ended boats, particularly double enders.You may specify end moments in the rep by specifying slope (rise/run=Y') or curvature(Y"). This may be done independently by selecting end condition code when entering the rep.

END CONDITION CODES

Code	Forward end	Aft end
0	Curvature	Curvature
1	Slope	Curvature
2	Curvature	Slope
3	Slope	Slope

Slopes are easier to lift from a drawing than curvatures and having direct power over end slopes will give some designers a greater feeling of control over some aspects of the design. Matching up the profile with the bow master curve is made easier. On the other hand slopes do not have simple default values like Y”=0, Z”=0 which give reasonable shapes without much thought. In our own design work we almost always use End Code 0.

3.8 USAGE

The only time we have used slope rather curvature is to define a barge like vessel with a parallel mid body. It was created in three reps, one for the bow, one for the constant midsection and another for the stern. By specifying Y'=0 and Z'=0 at the aft end of the fore body and the forward end of the stern section a perfect result was achieved. By the way, Auto3D can append the DRA files for each rep into a single file and produce the full lines drawing.

3.9 ACCURACY

Single precision floating point arithmetic is used hence accuracy is limited to 7 significant digits.

3.10 RESOLUTION

Screen Resolution is limited by the particular screen display you have. The resolution on the plotter is somewhat limited by the number of points calculated, this being the number of segments on the curve. The limit is 100. This means the section curves will be drawn by connecting up to 100 reference points with straight line segments.

3.11 FLAT SIDES AND BOTTOMS

Early versions of AutoSHIP/YACHT/BOAT had trouble producing exactly flat sided or flat panelled vessels, although you could come close. Now this problem has been solved. To get a perfectly flat side, adjust end moments and/or vertices in the LONGITUDINAL SPLINE routine in rep development tools. As you approach 0 curvature on the straight panel (variable threshold) the program matches the slopes between the vertices. This will produce perfectly straight offsets in the longitudinal direction between 2 or more vertices with 0 curvature. Some trial and error is still involved, but the graphic display makes it fast and quite easy. Clamping may be activated or deactivated in the settings menu.

3.12 PLANAR SHEER

This is a constant source of discussion between ourselves and other designers. As far as I know, only John Letcher,Chuck Paine and ourselves agree that a planar sheer line is a requirement for a pleasing hull line. A planar sheer is one which has curvature only in one direction, all in the same plane. This means that the sheer line always appears either concave or convex no matter what angle it is viewed from, without any S curves or humps. If the two curves (sheer in plan—Y plane and sheer in profile—Z plane) are designed independently then a non planar sheer is virtually certain, with attendant humps which appear from certain angles. For those who care AutoSHIP/YACHT/BOAT provides a method of designing a planar sheer. See EDIT/Display/Edit.

For a discussion of plane sheers see John Letchers SNAME paper titled Mathematical Hull design for sailing YACHTs, Jan 17,1981. It is interesting to note that virtually all Nat Herreschoff designed boats have a planar sheer, apparently because he carved a model of each one.Virtually none of L. Francis Herreshoffs designs have a planar sheer, probably because they were done entirely on the drafting board in two dimensions. Computers have brought us full circle since computer hull design allows us to tilt and rotate the "computer model" on screen, giving similar results to a carved model in a fraction the time.

Note: AutoSHIP/YACHT now has a new feature in the REP DEVELOPMENT TOOLS that can be used to automatically make the sheer or chines lines planar.

CHAPTER 4 TUTORIAL

LESSON I - START UP
DISPLAY OF LINES ON THE SCREEN
REVIEWING THE REP
EXIT

We have prepared the following "cookbook" instructions as a guide for a useful initial orientation to our hull design module. AutoShip/Yacht is large and complex, and its approach to hull design is so radically different from the traditional methods most Naval Architects are trained in that we find new users, presented with the program and documentation for the first time, are often confused and bewildered. A guided tour has proved a useful introduction for those we cannot train firsthand.

To follow this tour, try to key in the sequence of responses to prompts exactly as given below. At least at first, follow them exactly; don't worry overmuch if you don't understand why we make a particular choice. After awhile, as you get to see how the various features work and interact, feel free to go off on your own. You can always rejoin the tour by getting back to the Main Menu, usually by pressing <ESC> once or twice. If you get trapped some place and can't find the way out, you can press the reset button and start all over. There is NOTHING you can do from the keyboard that will damage the computer. If you keep a write-protect tab on the master program diskettes, there is nothing you can do to damage the program either.

A few hardware considerations: to run the program at all, you need a suitable computer for the disk supplied; this is indicated on the disk label. To see the screen graphics (which is used extensively in the tour), your computer will also have to be equipped to display high-resolution graphics. Plotting (on a pen plotter) is not included in the tour; it works much like the screen plots we will demonstrate, but of course produces an accurately scaled paper copy.

In the INSTALLATION section of this manual, you will find information about operating the program on various computer systems. Probably you will have to follow some of the instructions there to load the program into memory and let it know about the particular hardware you will be operating with.

To issue the MSDOS command for starting the program, type CD\GEN4 <cr>.

(Here's the first convention you need to understand — how we show what to type. First, we will try to underline everything that you type from the keyboard. Second, by <cr> we mean to press the carriage return key, usually marked ENTER or sometimes RETURN, or sometimes marked by a little arrow that turns down and to the left.)

At \GEN4>, type AMENU <cr>; then go to the RUN menu and select the **Hull design module**. As the program starts up, it will display the title screen. It also checks for the HARDWARE LOCK; if it is not installed, you will be so informed:

Lock not present — cannot save!!
[PRESS ENTER TO CONTINUE]

N/A
2003

If you have a lock and have just neglected to install it, put it in place and start the program again from AMENU.

If you are running a demo version (and therefore have no lock), you can go ahead and explore the program along with the tour, so press <ENTER>; the program will go on to the Main Menu (see below).

If the lock is present, the program will automatically go on to the Main Menu, which it presents at the top of your screen:

Files Edit View Calc Plot Settings

Each of these options is attached to a pull-down menu which offers several further options. To select from the Main Menu, simply type the first letter of the heading or use the right arrow to highlight your choice.

The first thing you need to do is to get a file in memory, so type F (or press the right arrow once) to see the Files Menu:

Load Rep
Create Rep
Save Rep
Delete Rep
PNL file out
OFE file out
BHS file out
ASHADE(tm) .DXF
Quit

First of all, you need to know that we use the term Rep (short for "Representation") to designate a fairly short table of numbers which represents a specific hull; the coefficients are used in the AutoShip/Yacht formulas. Several Reps are included with your copy of AutoShip/Yacht . These are what we will use as examples in this guided tour. If you are using the demo version of the program, some of the menu options, such as saving and working with the offset file, will be disabled; but you will be able to participate in the Rep editing portions of the tour. In case you need to stop mid-session for some reason, we've included the altered Reps on the disk, so you won't have to go back and type all the changes in anew.

So, let's load an existing Rep; type L <ENTER> or use the down arrow to highlight Load Rep and then press <ENTER>. The program will prompt:

```
Drive or directory to search [\GEN4\]?
```

Press <ENTER> and you will see a directory of Reps. Use the arrow keys to highlight DEMO.REP and press <ENTER>. The program will read in the file (a complete hull shape is now in the computer's memory!) and display a file summary:

REP STATUS

```
X Position of Station 0 =  1.949    Station Spacing  =  2.733
Number of Segments       = 10       B-Spline Order   =  2
Bow Rounding Code        =  0       Stern Rounding Code =  0
End Condition Code       =  0       Sections selected = 25
Master Curves    =  3               M.C. Control Points  =  4
Transom:  X = 29.200   Angle = 22.00 Degrees   Radius = 10.000
                DRA files currently attached:
                            NONE
```

Some of the headings in this table are probably not familiar to you. Don't worry about that now; we'll explain them in due time. For starters, let's just go see what the Demo Hull looks like.

Choose VIEW from the Main Menu by typing V (or by pressing the right arrow 3 times).

Choose: Screen Lines. Press <ENTER>

The program will shift into graphics mode and ask you to wait while it compiles the offset table from which it creates the screen display. Then it will present the Projection Menu at the bottom of your screen:

Projection:
(1)Body (2)Plan (3)Profile (4)Isometric (5)All

Type 5 <ENTER> to see body, plan, and profile views in one screen, at the same scale. If you are using a color monitor, each type of curve will appear in its own specific color. This set of screen lines includes the sheerline and transom, plus a selection of sections, waterlines, and buttocks. This is the set of curve types specified in the Curve Sequence choice of the Settings Menu. The number and placement of each type of curve was specified either when the Rep was first created in FILES/Create Rep or later in the Settings Menu. (We'll explore specifying a different set of curves in just a bit.)

This is a good time to point out a limitation of micro-computer "raster" graphics. In a graphics display such as the one you are looking at, the picture is formed by turning on specific dots (pixels) which are in fixed positions on the screen. The higher the resolution, the more pixels there are — but even on the highest resolution graphics the number is decidedly limited (say, 640

x 350). Since a line is displayed by turning on the set of pixels that best approximates the desired line, within the screen's set of available dots, what you see is only approximate. Especially when a line is almost horizontal (as in the sheer in profile) or vertical, you can see it jumping from one row of pixels to the next. The effect is called "jagging." It's the best the machine can do. Just remember that the lines inside the computer's memory are far smoother than what you see on the screen.

So here is the Demo Hull, represented to the best of your screen's graphics. She's a simple little sailing hull, 30 feet long and somewhat over 9 feet maximum beam. She was originally cooked up in about 5 minutes of computer time and has proved a trustworthy companion over years of program growth and demonstration.

When you have the 3 views of her on your screen at the same time, all you can do is look; but when you select a single view of a hull, you can move it around on the screen, to see it from different perspectives. Type 3 <ENTER> to screen up just the profile view.

The program will proceed to display the profile view with a list of function key manipulations at the bottom of your screen:

F1>Zoom+ F2>Zoom- F5>TltUp F6>TltDn F7>CW
F8>CCW Arrows UDLR

Press <F1> once. The screen image will be redrawn automatically, zoomed in. Press <F1> twice more. Notice that you do not need to wait for the program to redraw the entire image before you press another function.

This is a good place to explain another approximation in what you see on the screen. While the curves in the computer's memory are smooth, when they are displayed on the screen they are drawn as a series of straight-line segments; that is, the pixels that get turned on your monitor are approximating straight-line segments. Zoomed in as we are, you can begin to the segments, for instance in the buttock lines. We have a certain amount of control over the segments — the more of them we use, the shorter they will be and the more smooth the curve will appear. We will experiment with this a bit later on. For now, just remember that those buttocks (and all the other curves) really are smooth.

11 12

Press the left arrow 5 or 6 times to bring the bow into view. Press <F2> once to bring the image back to its original size and place.

You can also rotate the image. <F5> tilts the image up and <F6> tilts it down (this is like rotating the image around an axis that runs horizontally across your screen). <F7> rotates the image counter-clockwise and <F8> rotates it clockwise. The 4 arrow keys move the image up, down, right, and left on the screen. Play with these a bit, then press <ESC> to see the Projection Menu again.

All the views we've been looking at have been parallel projections; when we rotated them, they seemed to show depth, but what we saw was not a true perspective. For instance, the transom was always the same height, whether it was in the foreground or the background. The isometric view, which you might just as well go ahead and display now, also gives a sense of three dimensions but it also is not a true perspective view. If you want to see true perspectives of your hull, you need to save .DRA files and then read them in to Auto3D.

Now let's change the curves that are displayed. Press <ESC> to return to the Main Menu, and then type "S" to see the Settings Menu. Type "C" (or use the down arrow key) to highlight Curve Sequence and press <ENTER>. The program will display:

Curve Sequence	
Sheer/knuckle Outline	[YES]
Sections	[YES]
Waterlines	[YES]
Buttocks	[YES]
Transom	[YES]
Longitudinals	[NO]
Master Curves	[NO]
Rebate Line	[NO]
Trim to Cutline	[NO]
Show both sides (iso)	[NO]
Station to switch sides	[6]

YES indicates that all of the curves of that type are to be displayed in VIEW/Screen Lines; NO indicates that none are to be displayed. None is pretty straight forward, but what does "all" mean? Let's go back a bit. There are a couple of different places where you can specify the number and placement of curves. One of them is in FILES/Create Rep. Another is in the Settings Menu, so let's go back there; press <ESC>, then "S" again.

This time, choose Stations (X). The program will display a table of the currently selected stations, listing the section number, station number, and X-position of each. This is how the first 5 stations of the Demo Hull appear when you first load that file:

Section 1	Station	-1.000	X =	-0.784
Section 2	Station	-0.500	X =	0.583
Section 3	Station	0.000	X =	1.949
Section 4	Station	0.500	X =	3.315
Section 5	Station	1.000	X =	4.682

There will be a listing of function key uses at the bottom of the screen.

The list of stations you see on the screen is what "all" (YES in the Curve Sequence box) means, at this time, for Stations. Press <PageDown> to see the second screen of the list. Let's put in twice as many stations up forward and get rid of every other station from X = 4 aft.

In this table, you use the arrow keys to move the cursor, but for the first part of this operation, the cursor can be anywhere because what we need to do is insert a group of stations. Press <F1>. In the red dialogue box:

- type in -1 for FIRST
- press the <cr> key to move to LAST
- type in 1.25
- press the <cr> key to move to STEP
- type in .25
- press <ESC> to move back to the listing of stations
- press <PageUp> to see the first screen of the list (that's where the stations we've inserted are)

The group of stations you specified has been inserted into the list of stations; the duplicates have automatically been removed and the sections have automatically been renumbered.

Now, press the down arrow until the highlight is in Station 1.500. Press <DELETE>. The station will be removed and all successive sections will be renumbered. Go ahead and remove all the other non-integer stations after 1.5. You should wind up with 20 sections when you've finished.

Now, let's add a station right at X = 4. You can leave the highlight wherever it is; press <INSERT>. A copy of the highlighted station will be inserted into the list, its X-position automatically calculated. With the highlight in the X column of this station, type in 4.000. Press <F2>. The station will be sorted into its correct sequential position. Press <ESC>. (Note that when you Escape, the program automatically sorts the stations and discards duplicates, so using <F2> above only made it so we could <u>see</u> the inserted station in its proper place in the list.)

Choose SETTINGS again, and then Waterlines. You edit waterlines in the same way as you edited Stations. For now, DELETE all but the Z = 0 waterline. Press <ESC>.

In SETTINGS/Buttocks, DELETE the 5-ft buttock (i.e. Buttock 6 at Y = 5.000). Note that since the half beam of the Demo Hull is less than 5 ft, you will see no buttock change in the screen lines.

Now, go look at this new set of curves; in VIEW/ Screen Lines, choose (4) Isometric from the Projection Menu. Use <F1> and the left arrow to see a closeup of the bow sections, if you'd like.

All of the curve types we've looked at so far are probably quite familiar to you. Let's move on to a couple of other types that may be less familiar but are vital to the workings of this kind of hull design program.

Choose SETTINGS/Curve Sequence and turn OFF the following curves (use the down arrow to move down the list and the SPACE BAR to flip the YES/NO toggle):

Sections	[NO]
Waterlines	[NO]
Buttocks	[NO]

Leave ON or turn ON these curves:

Sheer	[YES]
Transom	[YES]
Longitudinals	[YES]
Master Curves	[YES]

When the window shows all the settings as you want them, press <ESC>.

Go to Screen Lines and choose the isometric projection again. The 3 green curves you see: (1) along the bow profile, (2) at midships, and (3) just beyond the transom are the 3 Master Curves that provide the essential geometric support for the hull. The first Master Curve (MC1) lies in the centerplane, forming the stem profile; the other two are transverse sections. Think of these as the basic framework of the shape, akin to molds, over which the program springs a series of longitudinal ribbands or battens.

The white, lengthwise curves are those battens; we call them longitudinals. 11 are displayed here, out of an infinite family which together form the continuous surface. Think of these longitudinals as thin round rods of uniform, weightless, springy material. For a full-size boat, you might think of them as being 1/4-inch, perfectly true, spring steel wires. Or you might imagine the process as building a scale model a couple of feet long, using dry (uncooked!) spaghetti for the longitudinals. They behave very much like drafting splines, except they bend just as easily in any direction, horizontally or vertically or otherwise. Their stiffness is what ensures us that the surface is very fair and smooth in the longitudinal direction, the direction that the water flows along, almost without regard for how we shape the Master Curves.

Now let's go look at the Rep for this hull and see how each Master Curve is specified by just a few points in space.

Pull down the Edit Menu and choose Edit Rep. This is the way to just see or to edit the Rep numbers directly. The editing keys and their functions are listed at the bottom of your screen, but this time we'll ignore them and just look at the Rep.

The entries in the Rep are displayed in a neat table, Master Curve by Master Curve. The bulk of the Rep is coordinates X,Y,Z for the control points or "Vertices" (singular is "Vertex") of the Master Curves. These dimensions are all in feet (though meters can be used just as well.)

The Demo Rep has (as we saw on the screen) only 3 Master Curves (the program allows up to 12). The first is displayed now; to see the next one, **press the down arrow 4 times (the highlight will jump down the Vertices of MC1 and from Vertex 4 (V4) will jump into MC2). Press the down arrow 4 more times to see the third Master Curve. The Master Curves are defined by just 4 vertices each. Each Master Curve can have up to 30 Vertices, but the Demo Hull gets by with just 12 for the whole boat. The additional information labeled Y" and Z" by the first and last Master Curves specifies ending curvatures of the longitudinals where they attach to the Master Curves. These are "tweaking" parameters which can often be left equal to zero.

Let's take a look at the numbers in a bit more detail. Use <PgUp> to move back to Master Curve 1. All its Vertices have Y = 0; it lies in the centerplane. V1 is at the stem head. Master Curve 2 is at X = 16; it is a transverse section. It runs from V1 on the sheer to V4 on the centerline. Master Curve 3 is also a transverse section, at X = 30, and it also runs from V1 on the sheer to V4 on the centerline.

Press <ESC> to return to the Main Menu. To exit the program, select FILES/Quit. Then Type "R" to return to DOS control.

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So here is the Big Picture: A few Vertex points are sufficient to define each Master Curve. A few Master Curves are sufficient to frame the hull. An infinite number of thin longitudinal splines sprung over these molds forms the surface. You control the shape of the surface by moving the Vertices; as you do so, the springiness of the splines ensures continuity and a high degree of longitudinal smoothness.

SUMMARY

Our hull design module is a powerful, flexible hull surface definition tool. Making screen displays of the surface you are creating is an essential way to interact with it. Using the built-in Demo Hull as an example, we learned how to choose different views and how to select from a broad array of curves that can be displayed in these views. We also took an initial look at the Rep for this particular hull and identified the role played by most of the numbers in it. Finally, we learned how to leave the program and return to MSDOS.

LESSON 2

Changing the Rep
Screen Editing of Master Curves
Rep Editing

This lesson starts with just the Demo Rep in memory. If you're already in the program, go back to FILES/Load Rep and reload the Demo Hull. We're going to change this hull into another boat altogether, in several steps so we can see the changes taking place.

Pull down the Edit Menu and choose Display/Edit. The program will switch to graphics mode and display the first Vertex (yellow crosses) of each Master Curve with a longitudinal spline (red) running through them. The cyan (light blue) line is a display of curvature distribution and the white line is the centerline (X axis). The bottom line of your screen lists the actions of the function keys.

Currently, you are in the Longitudinal Spline editing routine. From here, with the flip of a switch, you can jump into the Master Curve editing routine. That's where we need to be, so press <F10>.

Master Curve 1 (red) and its Vertices (yellow crosses) are displayed. The cyan lines are straight lines connecting the Vertices. The function key actions are similar to those of the Longitudinal Spline editing routine. For Master Curve editing they are:
F1>Move F2>Ins F3>Del
F4>Snap +Snap10x -Snap/10 F5>Next
F6>Last F7>XY F8>All F9>Zoom

Press <F9> to get a closeup view of the Master Curve.

Press <F1> to get into MOVE mode. A large magenta cross will appear on the first Vertex; it marks the position of the cursor. The horizontal and vertical coordinates (in this view, the X and Z coordinates respectively) of Vertex 1 are displayed at the top of the screen. At the bottom of your screen you will see the prompt:

New location for Vertex 1 (Arrows to move, <EN-TER> to select)

Press <F5> or 2 to jump the cursor to Vertex 2. Notice that the horizontal and vertical coordinates and the number in the prompt line change accordingly.

Let's move this Vertex (V2) to X = 0, Z = 1.388. Press the right arrow once. The cursor will move 0.1 unit to the right (in the negative-X direction); the value of the horizontal coordinate will change from 1 to 0.9. The size of jump the cursor makes is the snap value displayed in the top right corner of the screen. Press the plus (+) key to multiply the snap value by 10.

Now press the right arrow again. This time the cursor will jump 1.0 unit, to Horiz = -0.1. Press the minus (-) key to decrease the snap value by a factor of ten. Press the left arrow; this time the cursor will jump 0.1 unit in the positive-X direction, to Horiz = 0, which is the X-position we want. Now use the up arrow twice to move the cursor to Vert = 1.338 (i.e. Z = 1.338). Press <EN-TER> to accept the new position for Vertex 2 and the Master Curve will be redrawn with its new Vertex.

We have changed just one of the Vertices, the second one, on Master Curve 1, pulling it 1 ft forward and 0.2 ft upward while leaving Y, Y", and Z" alone. [This is our TUT2A.REP]

Go to VIEW/Screen Lines and compare the profile view with your memory of the Demo Hull (or go back to Lesson 1 and look at the picture). The bow profile, of course, has totally changed. In place of the relatively straight modern profile, this hull has a rounded apple bow that looks like it needs a bowsprit to finish it off. The rest of the boat is pretty much the same as it was. Note though, that there seems to be a small hollow where the Master Curve joins the last longitudinal. Moving Vertex 3 forward and up a bit might help here.

This time we'll edit the numbers in the Rep directly. Go to EDIT/Edit Rep. The first Master Curve is displayed and ready for you to edit. Use the down arrow to move the highlight to the third Vertex and type in 1.400 in the X column. Press the right arrow twice to move to the Z column and type in -0.520. Press <ESC> to accept the Rep with this new Vertex. [This is our TUT2B.REP]

Go back to VIEW/Screen Lines and display the profile again. Let's look at the bow in a little more detail. <F1> is the zoom in key; press it. Oops, the bow is no longer in the picture. (Remember that you don't have to wait for the program to finish the entire drawing before

you press another function key.) Press the left arrow 3 times, to get the bow to center screen; there's the closeup of the bow! The profile looks a little better now. Since we're going to make more changes, let's leave it and go on.

What's been going on behind the scenes as we've been making these changes to pull Master Curve 1 into a rounded shape? For one, the program has automatically adjusted the longitudinal splines to the change, so the lines of the hull are just as fair as when we started.

Go ahead and display all three views. You can see the strong resemblance of most of the hull to the Demo Hull, the specific change in the area where we moved the 2 Vertices, and the fairness of the new shape.

One thing that's wrong with these views is that the forward ending of the waterline is no longer at Sta. 0. Changing the shape does not automatically produce new stations registered with the waterline endings; the stations are still governed by the two Rep settings X-POSITION OF STA. 0 and STATION SPACING, which for the Demo Hull are 1.949 and 2.7326 respectively. Think of 1.949 as the forward overhang and 2.736 as 1/10 of the design waterline. To get a new set of stations we have to edit these entries and redo the station selection.

[Let's make a brief excursion to Calculations to get the data we need to fix this.]

Go to SETTINGS/Rep Settings. Set:

X-position of Station 0 = 1.1**
Station spacing = 2.817**

Then in SETTINGS/Stations, delete all the old stations and insert the group -1 to 11, step 0.5. [This is our TUT2C.REP]

Go back to VIEW/Screen Lines, if you like, and verify that the new stations do align correctly with the new waterline endings.

Next we are going to undertake a more serious change to this boat. By adding two more Vertices to each of the Master Curves, we'll transform her to an entirely different kind of hull with wineglass sections and a full keel.

Choose EDIT/Display/Edit and use <F10> to switch to MC editing. Since we're going to add 2 Vertices to all 3 MC's, it doesn't really matter which MC we have on the screen, so let's look at MC2 for a change. Press <F5> or 2. MC2 appears as a straight line in profile; press <F7> to exchange the X and Y axes on the screen display.

To add the Vertices:

Press <F2>; you will be prompted:

Insert new Vertex after Vertex # (0 to 4):
type 4 <cr>
Location for Vertex 5 (Arrows, <ENTER> A for all MC's)
type A
Proportional location for new Vertex (1=next) (0 to 1)
type 0 <cr>

The function key menu will appear at the bottom of the screen, but the crosses for the Vertices will appear no different than before. Recall though that we added V5 in the same position as V4. To see that it is indeed there, press <F1> to see the cursor. Then type:

2 to jump to V2
3 to jump to V3
4 to jump to V4
5 to jump to V5 (it is there! — look at the number in the message line)

Press <ESC> to get out of move mode.

Let's go see MC3 and its Vertices (it should have 5 now). Press <F5> and then <F1>. When the cursor cross appears, it will be on V5, since that's where we had left it when we finished looking at MC2. Press <F6> four times, to jump the cursor back up the Verti-

ces one by one. Yes, V5 not only is here, but it also is right where its supposed to be — right on top of V4!

Now go ahead and put a 6th Vertex on each MC. You can do it from right here on MC3. First, press <ESC> to get out of move mode; then press <F2> again and add a Vertex after V5, on All MC's, at 0 proportional distance (that is right on top of V5).

Press <F1> again to see the cursor. This time check on the positions of the Vertices by pressing <F5> to jump to each successive one. Vertices 4, 5, and 6 will be all in the same place. [This is our TUT3D.REP]

Just a note of review here, that when you are in MOVE mode, there are 2 ways to move the cursor from one Vertex to the next:

> (a) by typing the number of the specific Vertex(b) by using <F5> to move to the NEXT (next higher in number) Vertex or <F6> to move to the LAST (next lower in number) Vertex.

Escape from move mode and go to VIEW/Screen Lines. Display all 3 views together. Notice that the previously smooth curve of the topsides is now broken into several straight-line segments. What's going on? Remember the longitudinals we looked at in Lesson 1 (the infinite set of "ribbands" that go over the MC "molds" and form the surface of the hull model)? The addition of the new Vertices has caused the longitudinals to bunch up at the bottom of the hull. The key here is that the set of longitudinals saved with the Demo Rep, and therefore the set used in making the screen

drawings, is a small set of only 10. Let's go look at them.

In SETTINGS/Curve Sequence, set the following curves to [YES]:

Sheer/knuckle
Transom
Longitudinals
Master Curves

Set all the others to [NO].

Go back to Screen Lines and display the profile view. The bunching up along the bottom leaves very few longitudinals along the topsides. We can fix the picture by using more longitudinals. They will still bunch up at the bottom, but there will be more left on the sides.

Go to SETTINGS/Rep Settings and change the number of Segments to 30. Now take a look at the profile view again. You can see many more longitudinals along the side of the hull now (three times as many, in fact).

Go back to Rep Settings, turn off the MC's and longitudinals and set the following curves to [YES]:

Sheer
Sections
Waterlines
Buttocks
Transom

Back in Screen Lines, display the body plan [This is our TUT2E.REP]. The curve of the topsides appears much smoother now. The segmentation of the screen display did not reflect an inherent change in the hull. You can also see one other affect that adding the Vertices has produced — the flattened bottom of the hull. The doubling of the Vertices has created a small but real change in the bottom end of the MC's, and therefore also in the bottom of the hull. This is a true change in shape, not a phenomenon we can "fix" by changing a Rep Setting. In any case, we are going to change the shape of the hull further, so we don't need to worry about what it looks like now.

Let's go make some big changes in the hull. First, we'll give her some wineglass sections, by editing the Vertices of Master Curve 2.

In EDIT/Display/Edit, use <F10> to jump to MC editing, then 2 or <F5> to see MC2, <F7> to flip the X and Y axes, then <F1> to get into MOVE mode.

Start with Vertex 6 (press 6). Right now, this Vertex is at Y = 0, Z = -1.848; let's put it 0.45 ft outboard and 2.3 ft downward, that is at Y = 0.45, Z = -4.148.

First, notice that the snap value is 0.1; that will do just fine for moving to Horiz (Y) = 0.40, so go ahead and use the right arrow to jump the cursor over that far. Now, press the minus (-) key to change the snap value to 0.01 and then use the right arrow again to finish moving the cursor to its destination of Horiz (Y) = 0.45.

To move the Vertex to its new Z-position, press the plus (+) key 2 times to change SNAP to 1, then use the down arrow just twice to move the cursor to Vert = -3.848. (Don't worry about the cursor cross getting stuck at the bottom of the screen. Watch the numbers up top; they show that the Vertex is being moved, despite the stationariness of the magenta cross.) Press the minus (-) key to change SNAP to 0.1, and finish moving the cursor to Vert = -4.148. Press <ENTER> to accept the new position for the Vertex. The program will automatically redraw the Master Curve (it looks a little odd right now, and it will look odder still — but just wait until we've finished!).

Now that you've got the hang of it, move the other Vertices:

(Horiz) (Vert)

V5 to Y = 0.50,
Z = -3.048 (what a curve!)

V4 to Y = 1.20,
Z = -1.748
(well, that's sort of a wineglass, but we can "fix" it better)

V3 to Y = 3.61,
Z = -0.908
(much better! now one last little change)

V2 to Y = 4.91,
Z = 0.392 (there!!)

The adjustments we made to Vertices 4-6 pulled the hull down into a rough and inelegant wineglass shaped mid-section. All that was required to smooth the curve gracefully was adjustment of V3. The adjustment we made to V2 gave the hull a bit more tumblehome and a bit more pleasing sweep.

If you were to view the whole hull at this intermediate stage, it would look rather ridiculous (go ahead and do it, if you'd like). Let's move on to Master Curve 3 and finish building down the keel. Press F5 or 3 to see MC3.

On this Master Curve, we only need to change the position of one of the Vertices (V6) we've added to the curve; V5 doubled on top of V4 will allow the Master Curve to have a sharp corner.

We will move V6 in two steps. First, while you have the Master Curve in cross-section view, press <F1> and move V6 to Z (Vert.) = -4.868. Press <ENTER> to accept. Next, we want to move this Vertex forward to X = 28.5, but we can't do that in this view; so press <F7> to swap the X and Y axes. Use <F9> to zoom in, then press <F1> and move V6 to Horiz. = 28.5. Accept the new position. [This is our TUT2F.REP]

V5 and V6 on Master Curve 3 now form a sloping rabbet line for the lower longitudinals to end on. Note that this Master Curve doesn't lie all in one plane any longer. Most Master Curves do, for convenience, but it's certainly not required.

Now, go back to VIEW/Screen Lines and display the isometric view (if you'd like to add a couple more waterlines down on the keel, go ahead and do so: SETTINGS/Waterlines). You can see the full keel we've developed. The rudder would be carved out of the after end of it. The leading edge and bottom of the keel are formed by the last longitudinal, t = 1. The trailing edge is part of Master Curve 3.

While we're at this point, why don't you <ESC> and then display all three other views together. I wouldn't consider this boat quite finished yet; for example, you can see a bit of a knuckle where the keel (t = 1 longitudinal) joins the bottom of Master Curve 1. This could be corrected by sliding Vertices 5 and 6 on Master Curve 1 down along the profile.

Before we leave this hull, go back to SETTINGS/Curve Sequence and set Sections, Longitudinals, and Transom to [YES]. Show this curve sequence in isometric view. You can see how some of the longitudinals that begin in the bunch at the bottom of the stem run off through the centerplane at the trailing edge of the keel, while others flow up along the hull to the transom.

Now TUT2E.REP is a pretty hull for a schooner, but at 32 ft it's hard to justify a schooner rig. Let's think big — say, 96 ft LOA and 24 ft beam. We can do this in a jiffy with stretching factors. Tripling the length calls for an X stretching factor of 3. The Demo Hull has 9.6 ft of beam, and we haven't done anything to change

that; in fact our current hull has exactly the same sheerline as the Demo Hull. So the Y stretching factor should be 24/9.6 = 2.5. If we use a Z stretch of 2.333, we'll have a 133% increase in draft and freeboard. To make these changes, go to EDIT/Stretch/Shrink. At the prompts in the dialogue boxes, enter:

3 for the X multiplier
2.5 for the Y multiplier
2.333 for the Z multiplier

The program will automatically multiply the X-position of Station 0, the Station Spacing, and the End Condition values. TUT2F.REP is the result of these last changes. Go take a look at her lines.

SUMMARY

The main point of this lesson is the extraordinary flexibility of our hull design module. Starting with a modern 30-ft racer/cruiser, by adding 2 Vertices on each Master Curve, shifting a few other Vertices, and stretching we transformed the boat into a schooner that would have been at home fishing for cod on the Grand Banks. We edited one of the Vertices by typing the new numbers directly into the Rep; we edited the rest of the Vertices interactively on the screen.

Throughout the process, the longitudinal fairness of the hull was retained in a way that exempted us from ever having to think about it. One powerful way to create new hulls is to modify an existing one, and from this example it should be apparent that you can go almost anywhere you'd like.

LESSON 3 —

Bow and Stern Rounding
Longitudinal Spline Editing
Transom
End Conditions
Planar Curves

The first part of this lesson is a short exploration of the bow and stern rounding capabilities of AutoYACHT and AutoShip. Please note that Bow and Stern rounding is not available in AutoBoat. The second part is an introduction to the Longitudinal Spline editing routine, end conditions, and the planar curve function. In addition, we explain how to specify a transom.

Start with the Demo Rep in memory. Take a quick trip into VIEW/Screen Lines and refresh your memory of the Demo Hull; the plan view is the one we need to focus on, but go ahead and display all 3 views at once. Then escape back to the Main Menu and we'll tackle bow rounding.

Bow rounding causes the bow to be rounded in the Y direction (plan view). In the REP STATUS summary, you can see that the Demo Rep is stored with a bow rounding code of 0, which means that bow rounding is off. To change that, go to SETTINGS/Rep Settings and type in 1 for Bow Rounding; type 1 rounding is radius rounding.

Go view the lines again, all three views at once. I don't

see any change; do you? I hope not. This is because bow rounding produces a radius between the longitudinal and the stem facing. See illustration in Chapter 5 under Bow Rounding. If Master Curve 1 has no width in the Y direction, no rounding can take place. So, if we're to exercise AutoYACHT/SHIP's bow rounding capability, we've got to give Master Curve 1 some width.

Go to EDIT/Display/Edit, press <F10> to enter Master Curve editing, and <F7> so that we can edit MC1 in the Y direction (MC1 appears as a straight line in this view). MOVE:

MC1 V1 to Y = 0.6
MC1 V2 to Y = 0.1

Now go back to VIEW/Screen Lines and check her out, in plan view. Zoom in on that round bow. With a Bow Rounding Code of 1 we get the bow rounded with a parabolic arc. The size of the radius is controlled by the width of the stem facing, the Y offset of Master Curve 1.

Let's move to the other end of the boat and explore type 2 (B-spline) rounding in the stern. B-spline rounding is governed by 3 points:

(1) the Vertex on the 2nd to last Master Curve
(2) the Vertex on the last Master Curve
(3) an imaginary point on the centerline at the same X-position as (1)

To round just the last couple of feet of the stern, we

need to insert a new Master Curve two feet before the end of the hull; we'll put it at X = 28. Go to EDIT/ Display/Edit. We can insert a new Master Curve from right here where we enter the Longitudinal Spline editing routine. Press <INSERT>. You will be prompted:

> Insert new M.C. after M.C. no. (1 to 2) *(2)?
> type <cr>
> Insert MC w/ (C)onstant or (P)roportional X (*C/P)?
> type <cr>
> X-Position of new Master Curve?
> type 28 <cr>

What we've done is like setting 4 new ducks 1 each on 4 existing splines. It causes practically no alteration of the AutoYACHT/SHIP surface (although if we wanted to we could now edit the Vertices of this new Master Curve and change the hull quite drastically).

In SETTINGS, choose Transom Off (you can jump there by pressing T twice); then in SETTINGS/Rep Settings, type in 2 for Stern Rounding, to choose the B-spline type. Go see the lines now, all 3 views together. The stern is a rounded counter. In type-2 rounding, the rounding starts at the next-to-last Master Curve, in this case at X = 28 feet.

Let's change this a bit. In EDIT/Display/Edit, press <DELETE>; then at the prompt, type 3 <cr> to delete Master Curve 3. This may sound crazy, but now that you've gotten rid of MC3, let's put it back in again, but in a little different way and in a new position. Press <INSERT> and insert a MC after MC2, but this time choose Parametric X (type P <cr>). Now you will be prompted:

Proportion of distance between existing MC's (*0 to 1)

Type .5 <cr>.

Go see the screen lines again. Now the rounding is over the last 7 ft instead of the last 2 ft. Note that the profile still is unchanged.

Let's make another little change here. Go to EDIT/Display/Edit, use <F10> to edit Master Curves, and type 4 to choose MC4. Since we want to edit X and Z, stay with this straight-line view, but use <F9> to zoom in on it. MOVE:

V2 to X = 30.4, Z = 2.052
V3 to X = 30.4, Z = 0.332

This makes a nice canoe stern; go take a look (all 3 views). [This is our ROUND.REP]

In the second part of this lesson, we'll explore the half of EDIT/Display/Edit that we've been skipping out of with <F10>, editing of longitudinal splines. We'll also take a look at specifying a transom, editing end moments of longitudinals, and making a curve planar.

Go back and reload the Demo Rep. In SETTINGS/ Curve Sequence, turn clamping off. Now go to EDIT/ Display/Edit and leave F10 alone; we'll stay right here in the Longitudinal Spline routine. What you are seeing is the longitudinal that passes through the first Vertex on each Master Curve, in profile view (yes, this line is also the sheerline). Press <F7> and you will see the same longitudinal in plan view.

This is a good time to talk a bit more about what that cyan line on your screen means. As we mentioned in Lesson 2, it is a display of curvature distribution. It is plotted off the white baseline (X axis) and its sign is significant. Here are some keys to reading it:

Cyan Line	Meaning
All zero	Straight line
Constant horizontal	Parabolic arc
All above baseline	Concave upward
All below baseline	Concave downward
Crosses baseline	Inflection point (change of dir.)

As we look at the sheer and the display of its curvature, note that the cyan line is constant (remember that this line, too, is only as accurate as your machine can make

it), indicating that the curvature along the sheer is a relatively constant arc. There is no concentration of curvature at either end, or anywhere along it, for that matter. The line also is all negative, indicating the concave downward shape of the curve.

Let's change this curve. Press <F1> to get into MOVE mode (same as in MC editing). Press 2 to jump to the Vertex on MC2 and move it outboard 1 ft, to Y = 5.61. Press <ENTER> to accept the new position and the program will redraw the longitudinal and the curvature line. Now, let's move the Vertex on MC3. Press <F1> and then 3. Move this Vertex inboard to Y = 2.7 and press <ENTER>.

Notice that the curvature line is still all negative and still relatively constant, although your monitor no longer approximates it with a single straight-line segment.

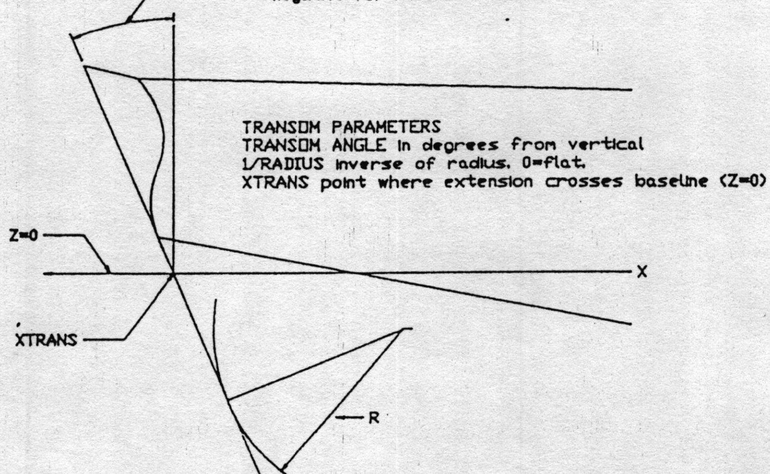
Go to VIEW/Screen Lines and choose All. We have stretched out the beam on deck by 2 ft, developing a lot of flare in the topsides. The transom is now quite wide. Let's go fix that.

Go to EDIT/Display/Edit and use <F10> to jump to Master Curve editing. Choose MC3 and use <F7> to swap X and Y. MOVE:

MC3 V2 to Horiz = 2.7
MC3 V3 to Horiz = 1.7

In VIEW/Screen Lines, you can see that with each of these Vertices moved 0.8 ft inboard, the transom is narrower, more in proportion with the hull. Still, she would look better with a reverse transom.

First, let's explain how we specify a transom in AutoYACHT/SHIP. There are 3 transom parameters (see illustration below):



PARAMETERS FOR TRANSOM DEFINITION

(1) X-position where the centerline of the transom crosses Z = 0 — this sets the longitudinal position of the transom.

(2) Transom Angle — this is the angle of inclination of the transom from the vertical; positive for a traditional transom, negative for a reverse transom.

(3) Transom Radius — this is the radius of the cylinder that cuts through the hull surface to form the transom; 0 gives a flat transom, positive gives a normal convex transom.

In the Settings Menu, Choose Transom On. You will be prompted for the 3 transom inputs in 3 dialogue boxes. Accept the defaults for X-position and radius (29.200 and 10.00, respectively) and enter -22 for the angle. Thus, the only parameter that is different from those saved with the Demo Hull is the transom angle, which we have simply made negative.

DON'T FORGET 'TRANSOM ON' IN CURVE SEQUENCE!

In VIEW/Screen Lines, display All. Our hull is becoming distinctly IOR-like. Let's continue making a few more changes in that direction.

Go back to EDIT/Display/Edit; press <F7> to see the sheer in plan view. We've played a bit with changing the curve of a longitudinal by moving the Vertices through which it runs. We can also control its shape by what we do with the ends of it. This is where End Conditions come in. AutoYACHT/SHIP allows you to specify end runout as either slope (rise/run = Y') or curvature (bending moment = Y"), at either end of the spline, so there are 4 possible combinations for the End Condition Code (part of the Rep Settings):

Code	Aftend	Fwd end
0	Curvature	Curvature
1	Curvature	Slope
2	Slope	Curvature
3	Slope	Slope

In our opinion, moments are usually easier to use, although there are a few special situations that require slope end conditions. Therefore, for most of our design work we choose an End Condition Code of 0, as we have specified for the Demo Hull.

Let's explore how changing values of end curvatures affects the shape of the Demo Hull these. Start with stern moments; press <F2>. The stern moment saved with the Demo Rep is -0.025. Press the minus (-) key to change the snap value to 0.01, then press the up arrow and watch the shape of both the spline and the curvature line. The 3rd time you press the up arrow, you decrease the stern moment enough to create an inflection point — it's difficult to see it in the red curve of the longitudinal spline, but the cyan curvature line lets you know that it is indeed there. Press the up arrow a few more times and the inflection at the stern will become large enough to see in the longitudinal.

Use the down arrow to bring Y' back to -0.025. Now continue "cranking" in on the end of the spline (with the down arrow). You can make the sheer bulge out quite a bit between MC2 and MC3, while it flattens between MC2 and MC1. End conditions are powerful tools!

When you've had enough of playing, bring the stern Y" to 0 (you'll have to decrease SNAP to .001 to finish) and accept it by pressing <ENTER>.

Let's move on to the bow; press <F3>. Change SNAP back to .01 (+), and play with the up and down arrows

again. Note that the curvature line will tell you of inflection before it's readily discernable in the longitudinal. Finally, accept bow Y" = 0.

We have relaxed the end moments of the sheer, letting both ends of the spline runout straight, thus straightening the curve and making it even more IOR-like.

Let's continue working on the sheer, but this time in profile view; press <F7>. We're going to move V2 up, to flatten the curve. Press <F1> (you may find that the cursor is already on V2; if it isn't, type 2). Set SNAP to 0.1 and move V2 to Z = 3.404. Now the curvature line shows 2 inflections.

Take a side trip into VIEW/Screen Lines and display the profile projection. Press <F7> 8 times to rotate the display. If you look carefully, especially in this final position, you can see the bumps and dips in the sheer; it oscillates. To our eyes, it's not very pretty this way; this is why we are advocates of planar sheerlines. In AutoYACHT, we've put in a routine that makes creating a planar curve extremely easy.

Go back to EDIT/Display/Edit; stay in the profile view. press the single letter P. The program will prompt:

```
Make this line Planar (Y/N*)?
```

type Y <cr>

The program automatically adjusts the end moments of the given longitudinal (in this case, the sheer) so that

the curve becomes planar. In this case, we wind up with Y" = 0 at both ends.

Go look at this in VIEW/Screen Lines, profile. Press <F7> 8 times again and notice that the lumps and hollows are gone; the sheer is now a lovely, sweeping curve when viewed from any angle. [This is our IOR.REP]

SUMMARY

In this lesson, we explored 4 more tools for defining and changing the shape of a hull surface. We saw how we could round the bow and the stern by using the Bow/Stern Rounding Codes, with either radius or B-spline curves.

Then we used the very powerful tool of the Longitudinal Spline editing routine to change the Demo Hull into an IOR racer. We found that the display of longitudinal curvature allows easy visualization of curve detail. We changed the shape of a longitudinal spline (the sheer) in 3 ways:

(1) by editing the position of Vertices
(2) by editing end conditions
(3) by using the "Planar" function

We also learned how to specify a transom by the input of just 3 parameters.

LESSON 4

Use of Curvature Display for Fairing Lines

In this part of the tour, we continue our exploration of the Longitudinal Spline editing routine. We'll focus on using the curvature display to help us fair lines.

Load DEMO.REP; go to SETTINGS/Rep Settings and turn clamping off (here's a trick: you can jump there by pressing the UP arrow once).

<INSERT> a Master Curve after MC2, at Proportional distance 0.

<INSERT> a Master Curve after MC1, at Proportional distance 1.

We have inserted 2 Master Curves almost, but not quite (note that the cross marking the Vertex on MC2 is a bit wider now), on top of Master Curve 2. The reason for "not quite" is that AutoYACHT/SHIP doesn't allow us to double Vertices or Master Curves absolutely; a new Master Curve is inserted a few thousandths of an inch away from the pre-existing one.

Go to EDIT/Rep Edit and see exactly where they are. You'll find one at X = 15.985 and the other at X = 16.014. The Y-values are 0.001 different from those of the original MC2; the Z-values are the same.

In VIEW/Screen Lines, notice that the lines appear unchanged. As we saw before, inserting new Master Curves makes (almost) no change in the hull surface.

Go back to EDIT/Edit Rep:

Change all the X-values of MC2 to X = 11.
Change all the X-values of MC4 to X = 21.

Go VIEW/Screen Lines, All [This is our JSL1.REP]
Spreading the 3 same-curve Master Curves apart creates a more or less parallel middle body, but it is decidedly wobbly. This is the way splines behave. We can use the curvature line in Display/Edit to help us fair these lines, so let's go do it.

In EDIT/Display/Edit, the sheer in profile (the spline through all the V1's) has 2 inflections. The curvature at MC3 needs to be fixed:

MOVE MC3 V1 down 0.1, to Z = 2.804. The curvature display still shows 2 inflections, but they have been shifted aft. Let's try moving the Vertex on MC4.

MOVE MC4 V1 down 0.1, to Z = 2.836. Now the curvature is all positive; the sheer in profile is now a continuous arc concave upward.

Let's look at the plan view (<F7>). This view also shows 2 inflections, again in the vicinity of MC3.

MOVE MC3 V1 up 0.1, to Y = 4.71. (Here's another little trick: move the Vertex in the direction opposite to the direction you want the curvature line to move. I.e. here we want the curvature line at MC3 to move downward, so we move the Vertex upward.) The curvature display still shows 2 inflections, but this time there has

been no particular shift in where they are — they're still on either side of MC3. Let's try moving the same Vertex a little more:

MOVE MC3 V1 up 0.1 more, to Y = 4.81. The curvature line is all negative now, indicating the spline is all concave downward. Let's see if changing the bow moment might make the curve a little nicer.

<F3>; use the down arrow to drop the Y moment 0.1, to -0.125. That's better.

Now let's go look at the longitudinal through the 2nd set of Vertices. <F7> back to profile view; 2 to jump to the 2nd line of Vertices. Again, we see there are 2 inflections, one on either side of MC3.

MOVE MC3 V2 down 0.2, to Z = -0.1076. That looks good; let's leave it.

<F7> to the plan view of this spline. There are the by-now-familiar 2 inflections.

MOVE MC3 V2 up 0.3, to Y = 4.91. That seems do the trick. Let's go on to the next row of Vertices.

<F7> back to profile view; 3 to see the V3's. Guess what!

MOVE MC3 V3 down 0.2, to Z = -2.0084. Keep that and flip to the plan view. Well, that looks a bit different! It does look as though moving the Vertices on MC2 and MC4 might do the trick:

2 3

MOVE MC~~3~~ V2 down 0.4, to Y = 1.409.
MOVE MC~~3~~ V~~4~~ up 0.3, to Y = 2.111. Amazing!

4 2

On to the last row of Vertices, in profile — <F7>, 4.

MOVE MC3 V4 down 0.2, to Z = -2.048. That looks pretty good, but if we move the Vertex on MC4 up a tad it will probably look better.

MOVE MC4 V4 up 0.1, to -1.7475. Now this looks pretty good! Let's see how she looks as a whole. [This is our JSL2.REP]

In VIEW/Screen Lines, display All. Not bad!

What we've done is a bit abstract, in the sense that we were fairing the lines between the Vertices rather than the lines on the hull itself. You might think of it as fairing the lines of a chine hull which cradles the actual hull we're creating. The sheer and profile of that chine hull cradle are exactly the same as those of the "actual" hull; and the "actual" hull is tangent to the chine hull at the mid-points of the panels. We faired the chines so they don't have any inflection points in either plan or profile view.

We can take a look at our chine-hull cradle. In SETTINGS/Rep Settings, change the B-spline order to 1 and the number of segments to 9 (or 12 — this needs to be a number divisable by the number of panels on the chine hull). Go back to VIEW/Screen Lines and display All. There's the cradle our new hull rests in.

SUMMARY

The basic idea of this lesson was to stretch the Demo Hull, not uniformly as with Stretch/Shrink, but so as to lengthen the midship portion. Just adding 2 molds (Master Curves) identical to the old Master Curve 2, at X = 11 and X = 21, didn't produce a fair hull because splines don't work that way. The curvature display showed us how to modify Master Curves 2, 3, and 4 slightly so as to "fair up" the resulting hull.

Chapter 5
PROGRAM OPERATION

To run AutoSHIP, AutoYACHT, or AutoBOAT, go to the Main Menu by typing:

CD Gen 4

then go to the Main Menu by typing:

AMENU

you will be presented with a program manager menu.

Coastdesign Program Manager

The Coastdesign program manager has four main menus: Run, Directory, Configure and Exit which is further divided into sub-menus.

RUN

AutoSHIP - Hull Design and Fairing
Auto3D - Orthographic & Perspective Display/Plotting
SEC - GHS Section Editor
OFED - Offset Editor
INTAB - Intact Stability Calculation
WEIGHT EDITOR - Weight and CG Calculation

Note that you can set up your own menu under RUN, to do so, please refer to Chapter 2 on how to edit the RUN menu.

The (UDLR) up, down, left, right arrow keys may be used to move around the menus. AutoYacht and AutoBoat will show a different RUN menu. Menu items also respond to the first letter of the item displayed. If more than one item begins with the same letter pressing the key repeatedly will cycle through the choices.

DIRECTORY

Set Directory for files
Display Directory

Set Directory for Files

A directory is a convenient way to organize your floppy or hard disk files. Directories allow you to subdivide your disk into sections, much the same way you might put groups of file folders into separate file drawers. For instance, you might want to put all your files relating to a series of design into a file called COAST. This way, when you type DIR on the DOS command line, you don't have to wade through hundred of file names looking for the file you want.

Before you can save a file to a directory, this directory must already exist. Your program is currently in a directory called GEN4. As you start on a new project, you may want to set the directory for your new files. Choose Set Directory for files, and you will be prompted for:

Directory for Data Files [\gen4\]?

The default is always the previous directory you saved files in. Accept the default or type in the directory name you wish to use for the current project.

DIRECTORY

Set Directory for Files

.... Creating a new directory

As we mentioned earlier, you cannot save your files to a directory unless it already exists. This calls for some advance planning. To create a directory, go back to DOS and from the C prompt type:

MD COAST

The MD command tells DOS to create a directory called Coast.

Display Directory

This option tells you the names of files that are in the current directory. You will be prompted:

```
Filename.ext to find [*.*]? ____
```

Suppose you want to find all the files pertaining to the DEMO hull. Type in DEMO and you will be presented with the following directory.

```
DEMO.DXF
DEMO.DRA
DEMO.REP
DEMO.PNL
DEMO.TXT
```

CONFIGURE

Hardware

The Configure menu allows you to go in and configure to the various graphics board, pen or printer plotter, digitizer and other hardware you have.

EXIT

Return to DOS

Takes you out of the program and back to DOS.

Highlight the program you wish to access by using the right arrow key or pressing the first letter of the heading. A pull-down sub-menu will then appear. The down arrow key may be used to move down to the desired selection, or press the first letter of the desired selection. For example, press S for Settings, or F for Files.

The <enter> key activates the selection. <esc> cancels the selection. After completion of an operation, you are always returned to this menu.

Files Edit View Calc Settings

Rep Status

None in Memory

Dimensions in Feet

Generation Four

This is the first menu selection. Upon selection of this prompt, the following sub-menu will appear.

- Load Rep
- Create Rep
- Save Rep
- Delete Rep
- PNL File Out
- DRA File Out
- OFE File Out
- BHS File Out
- ASHADE (tm).DXF
- Quit

Load Rep

Load Rep is the first command or selection in the Files Menu. We will start off by defining the term Rep.

What is a Rep?

A rep is a short word for representation. Rep refers to the compact table of coordinates that represents an AutoBoat, AutoYacht, or AutoSHIP surface. Rep files are created consisting of the master curves which describes a hull and an identifying message.

Here is a sample rep from our demo hull.

Vertex	x	y	z	y"	z"
1	0.000	0.000	3.960	-0.025	0.0066
2	1.000	0.000	1.188	-0.000	0.0000
3	1.800	0.000	-0.826	-0.100	0.0066
4	2.500	0.000	-0.898	0.000	0.0066

MC2

Vertex	x	y	z
1	16.000	4.610	2.904
2	16.000	4.610	0.092
3	16.000	1.810	-1.808
4	16.000	0.000	-1.848

MC3

Vertex	x	y	z	y"	z"
1	30.000	3.500	3.036	-0.0250	0.0066
2	30.000	3.500	1.452	-0.0100	0.0066
3	30.000	2.500	0.132	0.000	0.0066
4	30.000	0.000	0.132	0.000	0.0066

Load Rep

Load Rep loads an existing hull design or rep. Several sample reps are included in the program. Upon selection of this sub-menu, you will be prompted:

Drive or Directory to search [\gen4\]?

type in the name of directory where you store your reps, and a directory of reps will appear. You may make your selection by using the arrow keys to highlight the desired file, then press <enter>. If you decide not to read in a rep, then press <esc>. A rep status message will appear and access to the other menus will become possible.

Create Rep

Creates a new hull design. You will be prompted in turn to set the defaults, create the master curves (with digitizer or keyboard input), set the defaults, and make a table of selections. Prompts appear as follow:

Dimensions in (M/F) [feet]
Select M for metric, F for feet. Simply hitting the enter key means accepting the default prompt in brackets.

Number of Master Curves to Enter [3]
A minimum of 2 master curves is required to define a hull. The maximum number of master curves allowed by each hull definition program are: 8 master curves for AutoBoat, 12 master curves for AutoShip or Auto-Yacht.

The more master curves used and the closer they are spaced, the less automatic the longitudinal fairing will be. With 5 well spaced master curves you can do almost anything you want for sections and a fair surface comes out. There is not enough freedom for the surface to have lumps and bumps.

Create Rep

B-spline order for all MC's [2]
You are allowed to choose 3 different orders of B-spline when creating a rep.

B-spline order 1 master curve is simply a broken line joining the vertices. This is used principally for chine hulls.

B-spline order 2 master curve is made up of one or more parabolic arcs that join with continuous slope. Its shape is very closely linked to that of the broken line connecting the vertices. This is the usual choice for round-bottom hulls.

A B-spline order 3 master curve is a smooth curve with continuous slope and curvature. It is smoother than B-spline order 2 curve, but not so closely controlled by the broken line. It is occasionally preferred for round-bottom hulls.

Create Rep

Number of vertices on each MC [3]
In defining a hull, we use a series of master curves in space, each defined by a small number of control points known as "vertices" (plural of vertex). A master curve can be defined by as few as two or as many as 20 vertices in AutoBoat, or 30 vertices in AutoYacht or AutoSHIP.

The following constraints apply to master curves and vertices:

1. Two master curves may not intersect.
2. The master curves must be in order from bow to stern and must not cross over each other.
3. There is no general requirement that the master curves must have the same number of vertices, but chine vessels need the same number of vertices in order for the number of chines to remain the same.
4. It is easier to get a fair hull if the number of vertices is the same on all master curves and they are distributed similarly along the curve.

Create Rep

[No] Digitize input Y/N
Here you are given the choice of inputting a rep using the keyboard or the digitizer.

If you do not use a pointing device, the master curves will be created with all zeros. You should edit them entering the desired numbers (usually measured off a drawing) from the keyboard before going to screen lines, since **a rep with all master curves at x=0 is invalid** and will generate a warning message.

Please note that digitizer support is not available in AutoBoat.

Create Rep

How to create a Rep - 2 different methods.

If you are like most designers, you can hardly wait to get your own creation up on screen. Playing with the demo reps is just the beginning. There are basically 3 ways to begin designing a new hull.

Method 1. Entering a rep from the keyboard.

Entering a rep from the keyboard. Prepare a preliminary lines plan by hand, consisting of center and sheer profile, plan view of sheer and LWL, and sections at station 2,5 or 6,9 and the transom. Mark the B-spline vertices as shown in the illustrations, measure them with a scale rule. For those using imperial measure, 1/2" to the foot is a good scale as you can take decimal dimensions with Engineer's scale 20. Write down the XYZ coordinate of each vertex and enter them from the keyboard.

In some instances, you may wish to enter the rep of an existing boat by entering the numbers on the keyboard. This happens usually in cases when a designer wishes to communicate with another designer or builder who has the same system. He can send the rep by fax and the user at the other end will be able to display the hull in his machine in less than 5 minutes after entering the numbers on the keyboard. You will need to key in all the necessary Rep.

Create Rep

Method 2. Entering Master curves with a digitizer

Entering the rep with the digitizer is much faster and less error prone than keyboard entry. When you make the ***Create Rep*** selection, you will be asked whether a digitizer is used or not. Simply type **YES** for digitizer input.

Then you will be faced with a small menu which looks like this:

Profile (Bow to Right)
Section (Right of CL)
Section (Left of CL)

If you select **Profile (Bow to Right):**

You will be asked to calibrate the digitizer by the following prompts:

DIGITIZE KNOWN POINT ON BASELINE
(INSERT KEY TO ENTER)
Place the digitizer cursor or pen on the baseline at a known point (For example station 0). Press the digitizer button, or if using a pen, the <INS> key on the keyboard. This helps keep the coordinates from changing when the stylus is pushed.

HORIZONTAL COORDINATE OF POINT?
Type in the horizontal coordinate of the known point remember, if this is a profile, this is the X dimension. If your first point is station 0 you may wish to use it as your *ORIGIN* , the starting point of your X.Y,Z coordinate system. X positions forward of 0 will be negative while those aft will be positive. Station 0 could be at the bow, or the stern, or even at midships.

DIGITIZE SECOND POINT ON BASELINE
In order for the digitizer to be correctly calibrated, two points a known distance apart are needed. The second point could be Station 1 for example.

HORIZONTAL COORDINATE OF POINT?
Enter the next point from the keyboard. If, for example, you used station 1 and your stations are 3 feet apart enter 3.00.

If you are digitizing a **Section**, the first prompt will be:
DIGITIZE INTERSECTION OF BASELINE AND CENTERLINE.
You do not need to enter a coordinate here. It will be taken as 0.
The second point would be a half-breadth, for example buttock 3, along the baseline.

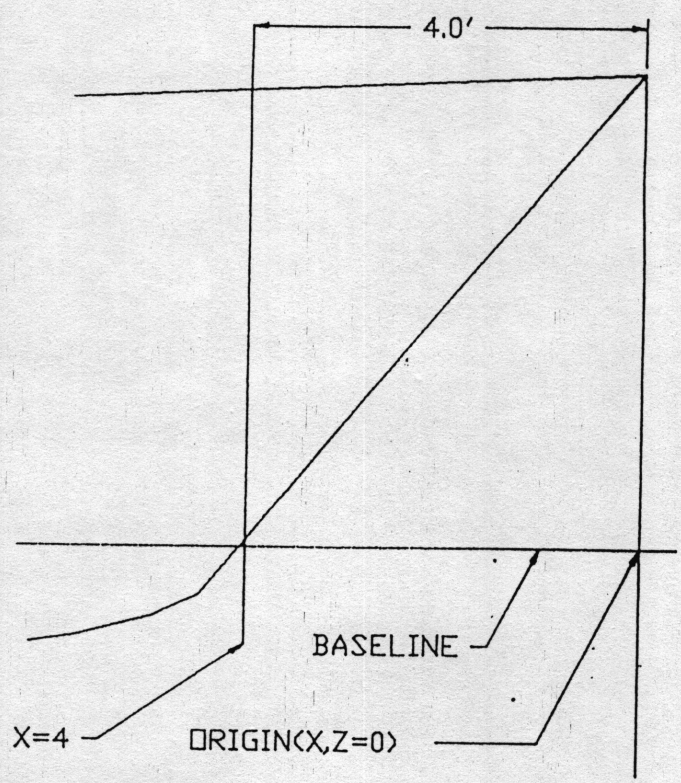
***Baseline**, n., the reference plane from whch all vertical (Z) measurements are taken. By definition, the Z=0 plane. The baseline could be at the DWL or below the hull, or even above the hull if you don't mind all your Z coordinates being negative.*

SAMPLE MASTER CURVES

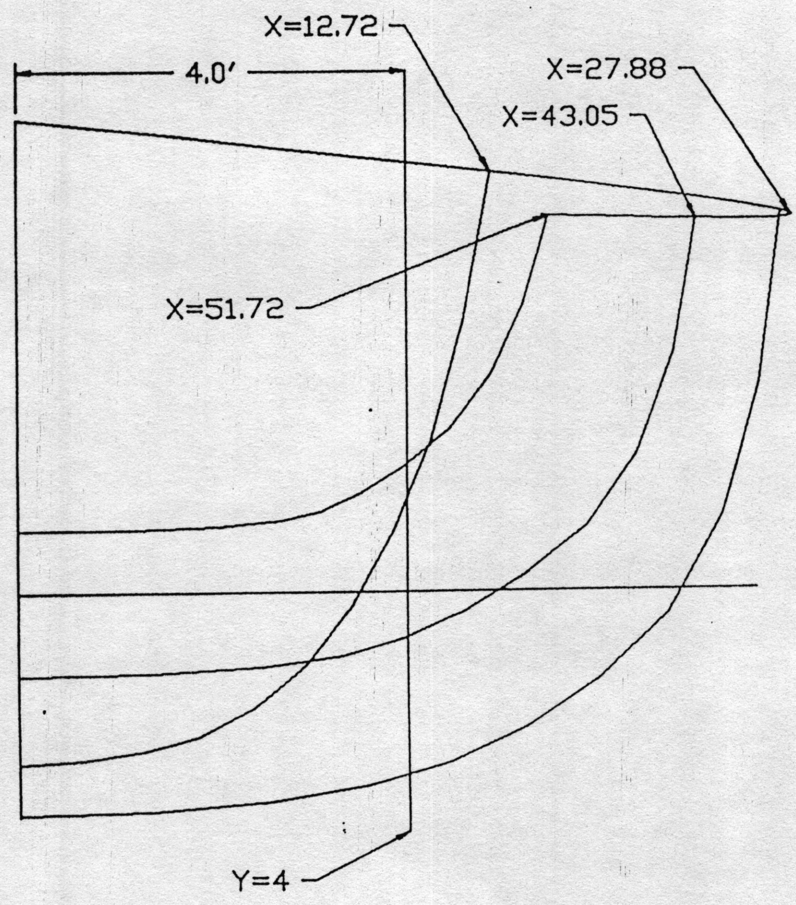
Here is a set of master curves to use when learning AutoShip or AutoYacht. Photocopy this page and use a colored pencil to mark your choice of vertices on it for entry. Tape the copy to the digitizer or measure the points with Engineer's scale 20.

Use X Position of Station 0 = 4.0 and station spacing of 4.33. Try using 5 vertices on each Master curve. After you have the rep in memory, be sure to save it. This boat is 52 feet long overall and about 15 feet in beam. Once you have entered the rep, display it on screen to check for entry errors.

Try changing the master curves to increase the displacement, or alter the prismatic coefficient. Run hydrostatic calculations, and try the plotter if one is available. Plot a drawing at 1/2" to the foot and compare it to the lines on the next page.



Profile (Bow to Right)



Sample Master curves for practice use (continuation)
Section (Right to Centerline)

Create Rep -
Creating a Rep using the digitizer

SNAP INTERVAL [.01]
SNAP - Snap is the minimum amount by which coordinates change with movement of the digitizing cursor. For example if y = 1, and snap is set at .01, the next increment will increase y to 1.01. A reasonable figure will be - say .02 (about 1/4") for feet, or .01 (10mm) for metric. The larger the scale of the drawing, the smaller snap can be and the more accurate the resulting trace. The reason for snap is that otherwise you will get coordinates with many decimal places and a difficult to read screen display. It also makes it more difficult to hit a desired dimension right on. On the other hand, setting snap too large will result in inaccurate master curves and an unfair hull.

Create Rep

You will next be prompted to give the rep settings in a table:

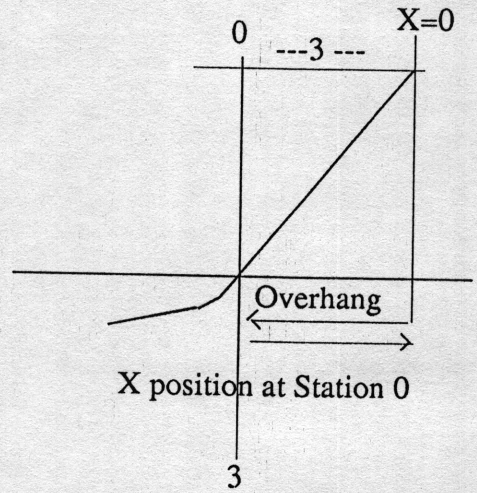
Dimensions in Feet	
X-Position of Station 0	[0.000]
Station Spacing	[1.000]
Number of Segments (1-100)	[20]
Deck camber in percent (0-50)	[5]
B-Spline order (1/2/3)	[2]
Bow rounding code (0/1/2)	[2]
Stern rounding code (0/1/2)	[0]
End condition code (0-3)	[0]
Clamping	[No]

An explanation of these settings will be found in the tutorial section.

Create Rep

X-Position of Station 0

If you have used the tip of the bow as your X-origin, then the X-position of Station 0 should be approximately equal to the length of the bow overhang. If you wish to locate Station 0 at the stern in European fashion, then this distance would be the distance from the bow to the aft end of the DWL. Other conventions are also possible.



Create Rep

Station Spacing

This is the distance between stations. 1 means 1 foot or 1 meter. The number of stations permitted in Auto-Boat is 40, and 120 in AutoShip or AutoYacht. If you exceed the maximum permitted, you will be warned and the number will be reduced to the maximum.

Create Rep

Number of Segments *

The number of segments is the effective "resolution" of the offset table. The more stations and the more segments, the smoother the drawing but the longer the calculations take. You can enter any number from 1 to 100. In the case of a B-spline order 1 hull, the number of segments should be a multiple of the number of panels on the hull where

number of panels = number of MC vertices -1

Deck camber

Refers to deck camber as a percentage of beam. 5% would be a typical value. 0 would give a flat topped transom.

* NUMBER OF SEGMENTS MUST BE A MULTIPLE OF THE # RESULTING FROM SUBTRACTING THE B-SPLINE ORDER FROM THE # OF master Curves I.E. —

10 MC's
− 3 B-spline Order
= 7

USE 7, 14, 2~~1~~, 28, ..., 49... etc.

Create Rep

Bow Rounding

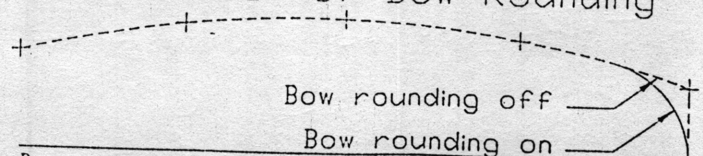
Bow rounding causes the bow to be rounded in plan view (y direction). It produces a radius between the longitudinal and the stem facing. If master curve 1 has 0 width in the y direction, no rounding takes place. The size of the radius is entirely controlled by the width of the stem facing, the Y direction of master curve 1.

Bow rounding uses a method which guarantees continuous slope at the intersection of the rounded section. The bow rounding is either a parabolic arc (bow rounding code 1) or may be related to the second master curve in the same way as stern rounding (bow rounding code 2).

You will be prompted to make a selection of the bow rounding code:

0 = none
1 = radius
2 = B-spline

The effect of Bow Rounding



Bow rounding is invoked by moving MC1 vertices off center.
The further off center, the larger the radius.
The illustration above shows how the radius is inserted, tangent to the longitudinal spline viewed in plan, and normal to the centerline.

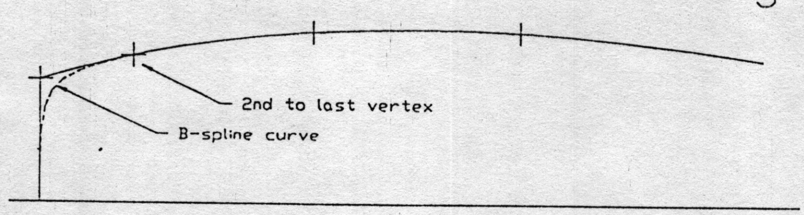
Create Rep

Stern Rounding

Stern rounding may be switched on in Master Curve 0. This operates slightly different from bow rounding in that rounding is a B-spline (order 2) which is controlled by 3 points (in plan):

1. 2nd to last master curve vertex
2. last master vertex
3. imaginary point on the centerline at the same X-position as (1)

The effect of Stern Rounding



End Condition Code

Besides passing through a specified set of points, a cubic spline needs one additional condition specified at each end. This can either be a slope or a bending moment. This hull design module allows either type of end condition at either end of the spline, so there are 4 possible combinations. For a more detailed explanation of end condition codes, see chapter 3.

End condition code as given in the following table reflects the nature of longitudinal spline control at the ends:

Code	Aft End	Forward End
0	Curvature	Curvature
1	Slope	Curvature
2	Curvature	Slope
3	Slope	Slope

The default set at end condition code 0 specifies curvature control at both ends (as also indicated by Y'' and Z'' in the vertex tabulations). A slope end condition would show as Y' and Z'.

Create Rep

Straight Line Clamping
When straight line clamping is enabled, areas between two master curves are clamped straight when the slope difference entering and leaving the "flat" area is less than .001. To show when this actually takes effect, the moment curve turns mauve rather than cyan in the affected area.

Save Rep

Save Rep allows you to save your rep or any changes you made to the rep into the computer memory. It is a good habit to save the rep every few minutes a a pre-caution. This way, if there is any unexpected power interruption in the middle of your work, you will only lose the portion of your work or changes that has not been saved.

Identifying Message
When saving rep, you will be prompted to give an identifying message for the rep. Identifying message allows one to store a more logical name since filenames are often cryptic being limited in the number of characters one can use.

You will be prompted:

```
Identifying Message: [Demo hull]?
```

```
File name for Rep [Demo]?
```

Refer to Chapter 2 on naming a file.

Delete Rep

Delete Rep allows you to delete a rep from a directory for whatever reasons e.g. the hard disk is full and you would like to save it to a floppy disk and delete it from the hard disk, etc.

First you will be prompted:

> Drive or Directory to search [\gen 4\]?

> [Yes] Delete \gen 4\name.rep?

PNL File Out

What is a PNL File?

PNL stands for the word Panel. The PNL File is a rectangular matrix of 3 dimensional points which describes the surface of a hull, keel, rudder, or other 3-dimensional panel. The matrix may have up to 256 x 256 points. PNL files are in binary format and thus may not be edited with the text editor. They can be generated by all Coastdesign programs which generate surfaces. This includes AutoYacht, AutoShip, Superfoil, Nacafin.

How to use a PNL file?

The PNL file is used by AutoShip/Yacht to show more than one surface simultaneously. For example, Attached PNL files could include keels, rudders, bulbs, and any other appendage which is part of the hull but not continuously faired. There are some sample PNL files included in your program diskettes such as a DEMOK.rep (which is a keel for the demo rep). Try playing with this rep by going to the Display/Edit Menu and selecting Attach PNL File. This will be discussed in more details under the Display/Edit Section.

PNL File Out

How to Create a PNL File?
To create a PNL File, first select the PNL File Out option. You will be prompted:

Filename for PNL File [Demo]?

The default is usually the name of the rep you are using. Accept the default unless you want to call it another name.

Drive or Directory for file [\gen4\]?

[Yes] File already exists. Replace it?

This prompt only coms up if file already exists. If you have made changes to the rep, type Y to replace the existing file. Otherwise, type N and you will exit out of the routine without writing a new file.

PNL File Out

Identification Title for PNL File

The PNL File has a three letter identification title. Sample IDs could be HUL for hull, KEL for keel, and RUD for rudder. You will be prompted to give an ID title when you create the PNL file.

```
3 Letter ID for this part [HUL}?
```

DRA File Out

What is a DRA file?

A DRA file is a three-dimensional wireframe representation for use by Auto3D. This file allows the vessel to be displayed in the same manner as on the AutoYacht or AutoShip screen. However, Auto3D also allows perspective views and includes the ability to generate CAD files.

When to create a DRA file?

All the views you've been looking at in AutoBoat, AutoYacht or Auto3D have been parallel projections. Although they give a sense of three dimensions, they are not true perspectives of your hull. If you want to see a true perspective view of the boat, you need to create a DRA file and then read it in to Auto3D.

A DRA file is needed when exporting to a CAD program. Auto3D reads in a DRA file and exports a DXF file for use in the CAD program.

DRA File Out

How to create a DRA file
Simply choose the DRA File Out selection and you will be prompted:

> File name for DRA [ ]?

> Drive or Directory for file [\Gen4\]?

> [No] File Already exists. Replace it?

These prompts work the same way as in PNL File Out. Please refer to the PNL section for details.

FILES

OFE File Out

What is an OFE File?

An OFE file is a station oriented offset file which is used by the programs such as the LPP (Lines Processing Program) of AeroHydro.

Coastdesign's OFED program can be used to edit the OFE file and output the result to draw BHS formats.

How to create an OFE File?
Simply choose the OFE File Out selection and you will be prompted:

```
File name for OFE?
```

```
Drive or Directory for file [\gen4\]?
```

```
[Yes] File already exists. Replace it?
```

BHS File Out

What is a BHS File?
A BHS file creates a BHS geometry file of the hull rep for use with AutoSHIP GHS. This feature of only present in AutoSHIP.

The BHS file can be used in AutoSHIP GHS to input the hull definition into Partmaker to create appendages, superstructure, multiple hulls, compartments and tanks. This can also be exported to BHS to calculate hydrostatic properties. See GHS manual.

How to create a BHS file?
First you will be prompted:

```
I.D. Message/Date (no commas) [Demo hull]
```

```
name.ext for BHS file [demo]
```

If no extension input, .BHS is assumed.

```
Drive or Directory for file [\gen4\]?
```

```
Shape name (max 8 chars) e.g. hull, kee, bulb, etc.
[hull]
```

Before you exit, you will be given a chance to save your file:

```
Quit [yes] save rep before exit?
```

ASHADE.DXF

What is AutoSHADE?
ASHADE is a rendering program supplied by Auto-DESK Inc. that converts AutoCAD (tm)'s three dimensional lines drawings into realistic pictures that show perspective, surface shading, and specular reflection.

How to create an AutoSHADE file?
First you will be presented with the following choices:

Body Plan Plan View Profile View

You will be prompted for the name and the directory you wish to save it under.

File name for DXF file [Demo]?

Drive or Directory for file [\gen4\]?

TEMP File Directory must be set to an existing Dir or DXF Out will not work!

EDIT

The EDIT routine is the area where the naval architect spends most of his time. Here you are able to read in an existing rep and edit it until you have what you want . You can add or delete master curves, change station spacing, stretch/shrink independently in 3 planes, and generally move things around until you are happy.

The EDIT Menu looks like this:

- Display/Edit
- Edit Rep
- Print Rep
- Move Origin
- Stretch/Shrink
- Reduce By
- Trim By
- Attach PNL Files

There are really two parts to this editor.

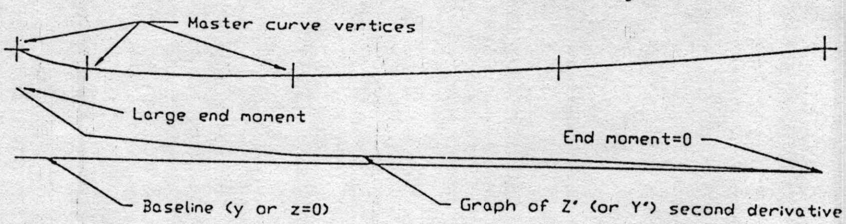
1. A routine which shows **Longitudinal Splines** through the master curve vertices.
2. A routine which displays the **Master Curves.**

You can switch from one routine to the other instantly by toggling the F10 key.

Before using this portion of the program, load a sample rep (i.e. DEMO) and familiarize yourself with VIEWS and SETTINGS. Then make some changes using the function keys.

Longitudinal Spline

How curvature is displayed



Function Keys:

F1 Move Point   F2 Stern Moment   F3 Bow Moment
F4 Snap   F5 next   F6 Previous
F7 Flips to alternate view (y or z)
F8 Switches on master curves
F9 Zooms in (left and right arrows pan)
INS inserts new Master Curve
DEL deletes a master curve (Minimum 3)
Arrow keys move a vertex up/down/left right by SNAP
Up/Down arrows set end moment
+/- keys multiply/divide SNAP by 10

Display/Edit

Jumps straight into the longitudinal editing routine at the sheer line.

Longitudinal Spline Routine

When the longitudinal spline is displayed on screen the function keys allow the end moments to be changed, vertices moved and the new curve instantly replotted.

The display shows the spline in RED. The centerline (plan view) and baseline (profile) are white. The CYAN (light blue) line is a display of curve distribution. Only the designer can decide the desirable curve distribution, but in a general way, here are the meanings of the distribution.

Curvature	Meaning
Zero	Straight Line
Constant (horizontal)	Arc
Crosses baseline	Change of Direction

Longitudinal Spline Routine Function Keys:

F1 MOVE VERTEX
After pressing this key, the cursor appears at the last master curve edited (1 if none was selected) and the F5 and F6 keys are used to move from point to point. While in the MOVE VERTEX prompt, the <del> key can be used to delete the master curve selected by the cursor. If you have only two master curves, the <del> key will not function since this is the minimum.

F2 STERN MOMENTS
After pressing this key, changing end moments affects the left (stern) (X=+1) end of the spline.

UP and DOWN Arrows
Add or subtract end moments by the amount of *snap*.

F3 BOW MOMENTS
After pressing this key, changing end moments affects the Bow (stern) (X=-) end of the spline.

F4 SNAP
Enter *snap* interval

F5 NEXT VERTEX
Changes display to next vertex down the hull.

Longitudinal Spline Routine Function Keys
(...Continued)

F6 **LAST VERTEX**
Changes display to previous vertex.

F7 **Y/Z FLIP**
Flips from Y (Plan) to Z (Profile) view and vice versa.

F8 **ALL**
Displays all the master curves on screen in green. Longitudinal lines join them in the master curve editing section.

F9 **ZOOM**
The F9 key doubles the magnification and zooms to bow or stern. Use the left and right arrows to change views. Another push on F9 returns to a full screen view.

F10 **FLIP**
When displaying master curves or longitudinals, the F10 key will flip you to the other routine in a single keystroke. This allows instant comparison between the sections and the longitudinals.

Display/Edit

Longitudinal Spline Routine Function Keys
(...Continued)

<INS> key

Inserts a new master curve after a selected curve. You will be prompted for constant or parametric X-position. If you select parametric X-position, you will be asked for the proportion of distance between existing master curves. A proportion of 0 will make the new master curve identical to the next master curve. A proportion of .5 will place the new master curve exactly half way between the existing curves and so on. Inserting a new master curve does not immediately change the shape of the hull but it does give you additional control points to manipulate. This routine can only be used when you have equal numbers of vertices on each master curve.

<Enter>

Hit the <Enter> key to record changes and redraw the curve.

<ESC>

Generally backs out or cancels an operation.

Display/Edit
Longitudinal Spline Routine Function Keys
(...continued)

SNAP + key - key

is multiplied by 10 by the + key and divided by 10 by the - key.

"P"key Planar Line

Modifies the Z values and end moments of given longitudinal line (i.e. the sheer line). If you have more than 3 master curves you will be prompted for "Governing Master Curve". The plane will pass through the first, last and governing master curves, which will not be changed. The Z values of the other master curves at the displayed vertex will be altered, as will the end moment.

"O" key Origin

Allows you to move the entire vessel independently in each axis. This routine differs from "Move Origin" in the EDIT MENU in that the stations, X position of Station 0, and transom are not moved. This is mainly to be used with keels or appendages to allow them to be easily matched to a hull.

F1 "R" key Relax

the equivalent of lifting the spline weight off your spline. Press F1 key first to bring the cursor on the screen, then press the R key. This relaxes the spline to its natural curve and reinsert the weight at the relaxed point.

Longitudinal Spline Routine Function Keys
(... continued)

"S" key Show

Display any attached DRA or PNL files on screen along with your master curves. Again, most useful for attaching a keel to the hull. The EDIT REP MENU has a prompt for AT -TACH PNL FILE where you can specify the names of the PNL files to attach. Make sure the PNL files actually exist before attaching them.

"C" key Cutline

The cutline is a B-spline with 2 to 20 vertices, defined in PROFILE only. The main use for this line is to allow the design of vessels with broken sheer lines and cut down sheers without disturbing the fairness of the surface. This is not possible with most other lines fairing programs since placing two or three vertices together on a B-Spline as used by MacSurf, FastYacht and most other systems inevitably results in a "break" in the surface, rather than just in profile as desired. The AutoSHIP cutline avoids this problem and is much easier to use as well, since you are manipulating a simple 2D spline. The program takes care of the surface intersection for you, and trims off all parts of the lines plan above the line.

Longitudinal Spline Routine Function Keys (...continued)

"V" **VIEW**
Causes a quick offset table to be calculated and the results displayed. The plan view shows waterlines, the profile shows buttocks, and the body view shows sections. The lines shown are the ones set in the SETTINGS menu. If LONGITUDINALS are on in the Curve Sequence they will be displayed in any view.

Restrictions and Rules on Using the Cutline Routine
The cutline may intersect any edge of the hull (bow, sheer, transom or stern, bottom, but:

1. It must intersect the hull boundary **twice** (not more, not less) in order to work correctly.
2. The line must begin forward and end aft.
3. You may intersect the bow and stern curves only once each (sheer may be crossed twice).

Display/Edit

Longitudinal Spline Routine

Creating a Cutline

The cutline routine is accessed from the Longitudinal spline routine in Rep Development Tools.

1. When in the screen display of a longitudinal spline, press the "C" (for Cut) key on the alpha keyboard.

2. If a cutline is already defined it will appear on screen and you will be in edit mode. If no cutline is defined, a cursor will appear at the origin and you will be prompted to "Locate the start of the cutline."

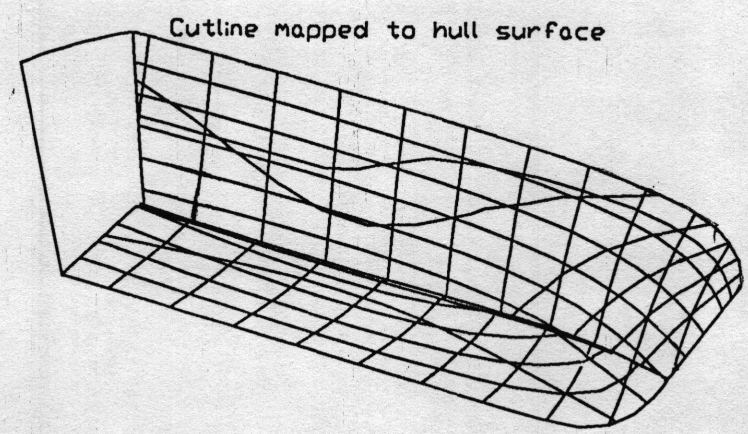
3. Use the arrow keys to move the cursor to a starting point. Press <enter>.

4. You will be asked to "Locate the end of the cutline." *(Do not worry too much about precision at this point as it is easy to change later.)* Use the arrow keys to move the cursor to a point. Press <enter>.

5. Then you will move to edit mode.

Note: Additional vertices may be added as required to complete the cutline. Since the cutline is a B-spline order 2 curve, a hard corner may be created by placing two vertices at the same spot.

Creating a Cutline



Display/Edit

Longitudinal Spline Routine

Editing a Cutline

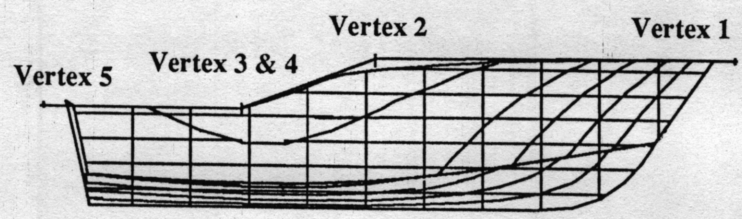
Function Keys follow the same conventions as when editing a master curve.

When no function key has been pressed, the up and down arrow keys move the entire cutline vertically by the amount of snap.

Editing cutline function keys:

F1 MOVE VERTEX
Arrow keys move the point.
+ and - keys change the interval (snap).
<enter> accepts the change.
<Esc> escapes without changing the line.
The X and Z coordinates of the cursor are displayed in the upper right corner of the screen.

Editing a Cutline



Cutline Editing
Note: Double vertices allow hard corner.

Display/Edit

Longitudinal Spline Routine
Edit Cutline Function keys
(... continued)

F2 INSERT key

1. Inserts a vertex. You are prompted:
   "Insert a Vertex after Vertex #(1 to __)"

2. Select a Vertex number and hit <enter>.

3. Then you are asked for a number from 1 to 0 representing the proportional distance between vertices.

   0 will cause the new vertex to be the same as the one selected above.

   1 will cause it to be the same as the next one

   .5 puts it half way.

The limit, which you will probably never need, is ~~20~~ 30 vertices.

Display/Edit

Longitudinal Spline Routine
Edit Cutline Function keys
(... continued)

F3 **Delete Key**
Deletes a vertex. You are prompted for which vertex to delete. A nil response results in no deletion.

F4 **Set Snap**
Prompts for entry of a specific snap interval. This may be used in the event you wish to move in specific intervals such as 1" (.0833). Otherwise it is easier to adjust snap with the + and - keys on the numeric keypad.

F5 **Next**
Only in operation after pressing F1.
Take the cursor to the next vertex.

F6 **Previous**
Only in operation after pressing F1.
Take the cursor to the previous vertex.

Display/Edit

Longitudinal Spline Routine
Edit Cutline Function Keys
(... continued)

F9 **Zoom**
Zooms in to double the magnification.
Another press returns to normal.
The left and right arrows select which end of the boat is on view, right for bow and left for stern.

Deleting a Cutline:

Just delete vertices until it disappears. The minimum number of vertices is 2, so when you get down to one, the line disappears.

Display/Edit

Edit Master Curve Routine
The first part of this section deals with the Longitudinal Spline Routine of this Editor. Now we will deal with the second part of this Edit Routine, the Edit Master Curve.

You can switch from one routine to the other instantly by toggling the **F10** key.

In the Edit Master Curve Routine, the individual master curves are displayed in profile or body view.

The RED line is the **actual curve** (the hull surface),
the YELLOW crosses are the **vertices**, and
the CYAN line is a **straight line connecting the vertices.**

Display/Edit

Edit Master Curve Routine
Function Keys
(... Continued)

F1 MOVE VERTEX

1. A cross-shaped cursor will appear at the vertex selected. Use the arrow keys to move this cursor to the location where you wish to put the vertex.

2. To move the cursor faster, hit the + key. To move it more slowly, hit the - key one or more times.

3. Each time you hit the + or - key, the amount the cursor moves at each push of the arrow key is either multiplied or divided by 10 from its initial starting value of .1.

F4 SNAP

The coordinates of the cursor location are displayed on line 3 of the screen as well as the snap distance. If you wish to enter a specific snap distance such as .083 which would represent 1 inch use **F4** and then input the number from the number keys.

Display/Edit

Edit Master Curve Routine
Function Keys
(... Continued)

F2 INSERT VERTEX
Selecting F2 allows you to insert an additinal vertex in the master curve. You will be prompted:

Insert new vertex after vertex no. (0 to 4):

1. Choose a location for the new vertex. If you select 0, the new vertex will become the first one on the master curve. Generally the first vertex represents the sheer line. When you select a vertex after which the new vertex should appear, the cursor will appear on screen and again you move it to the new location and hit the insert key.

2. If you hit the "A" key, a new vertex will be inserted on all the master curves. You will then be prompted for a proportion between 0 and 1 for the location of the vertices.

If you enter 0 the new vertex will be identical with the vertex selected above.
If you enter 1 the new vertex will be identical to the NEXT vertex.
If .5 then the new vertex will be on a straight line mid way between the selected vertex and the next one. The curve will immediately be re-displayed with the changes.

Edit Master Curve Routine Function Keys

F2 INSERT VERTEX
(... Continued)

Note: Although not strictly required (translation: It won't crash if you don't) we recommend using the SAME NUMBER OF VERTICES ON EACH MASTER CURVE! In addition, the vertices must be at THE SAME RELATIVE POSITION ON EACH MASTER CURVE. This is particularly important with vessels that have a chine or knuckle line. The chine or knuckle line must always fall at the same vertex number on each master curve.

F3 DELETE VERTEX

Selecting F3 allows you to delete any of the vertices on screen. You will be prompted:

Vertex number to delete (1 to 4):

Select the vertex number to delete and hit <enter>.

Delete this vertex on all Master curves? (Y/N*)

If you reply Y, the corresponding vertex number will be deleted on all the master curves, otherwise only on the one you are currently editing. The curve(s) will be re-displayed with one less vertex.

Display/Edit

Edit Master Curve Routine
Function Keys
(... Continued)

F5 **NEXT VERTEX**
Changes display to next vertex down the hull.

F6 **LAST VERTEX**
Changes display to previous vertex.

F7 **XY (FLIP VIEW)**
Changes from body to profile view and vice versa.

F8 **ALL**

Pressing the F8 key toggles a display of the other master curves (only the vertices, not the faired curves). This allows you to view the relationship of one master curve to the next. Only the MC you are currently editing appears in color.

Bear in mind that playing with these vertices does more than simply display them on screen. It also changes the numbers in the rep. However, unless you do a save rep, the changes will not be permanent. To see the effect of your changes on the hull, hit the <enter> key several times until you get back to the main menu. Then select screen lines as previously discussed.

Display/Edit

Edit Master Curve Routine Function Keys

F9 **Toggles**

Toggles scaling between full screen and zoomed in on the master curve being edited.

F10 **FLIP**

When displaying master curves, the F10 key will flip you to the longitudinal spline routine in a single keystroke. This allows instant comparison between the sections and the longitudinals.

<ESC>

Allows you to exit from the routine without changing the master curve.

"D" **DEADRISE ANGLE**

Only operable in body view, with the cursor visible on the vertex. Deadrise angle shown refers to the next panel down the hull.

"V" **VIEW**

Causes a quick offset table to be calculated and the results displayed. The plan view shows waterlines, the profile shows buttocks, and the body view shows sections. The lines shown are the ones set in the SETTINGS menu. If LONGITUDINALS are on in the Curve Sequence they will be displayed in any view.

Display/Edit

Edit Master Curve Routine Function Keys

"S" **SHOW**

Display any attached draw files on screen along with your master curves. Again, most useful for attaching a keel to the hull. The EDIT REP MENU has a prompt for ATTACHDRA FILE where you can specify the names of the DRA files to attach. Make sure the DRA files actually exist before attaching them.

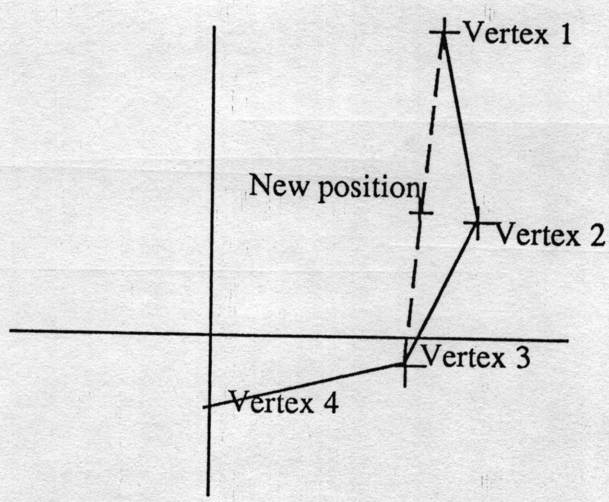
"C" **TOGGLE CURVATURES**

Shows the curvatures alaong the master curves in graphic forms, on a logarithmic scale which exaggerates small differences. The curvatures are particularly useful for editing a master curve which has too many vertices. The actual master curve vertices are used as a base line.

Display/Edit

"P" Proportion key

Allows a vertex to be placed on a straight line between 2 other vertices. P prompts you for a proportionate number.
To use this routine, first press F1 to bring the cursor on the screen. Use the F5 and F6 key to move the cursor around and then press the P key.



An example of when to use the Proportion key is when you need to put three vertices in a straight line.

You will be prompted:
New location. Proportional location of vertex (0 to 1)
0 duplicates the previous vertex
1 moves the vertex down
Using the imaginary dotted line as shown on the illustration above, 0 would be right on the top, .1, .2, .3, .4 ...... .9, 1 would be right on the end of the line.

Edit Rep

Brings the master curves on screen in text form, allowing you to change vertices by typing in new numbers.

The **arrow keys** scroll around.

<ENTER> key records a change and moves down.

<DEL> deletes a vertex.

<INS> inserts a duplicate vertex which may then be edited.

<ESC> returns you to the main menu.

When you scroll to the end of one master curve, the next appears.

Print Rep

Prints the master curves out for refrence. A hard copy of the rep is useful for reference and may be "faxed" to Coastdesign when requesting assistance.

Move Origin

Allows the entire hull to be "MOVED" in space. The origin is the point at which X=0, Y=0, and Z=0. The purpose of Move Origin is to re-establish the baseline or location of the vessel in space, or simply changing the frame of reference. Transom, cutline, etc. are moved too. Basically, new X,Y and Z coordinates are added to those already there. You will be prompted for a distance to move the coordinates, independently in X (longitudinal), Y (lateral), and Z (vertical) axes. X will move the vessel longitudinally, Y will move it athwartship, sometimes desirable to produce a narrower boat without disturbing the master curve. Z is used to raise or lower the boat thereby creating a new baseline.

Upon selection of this menu, you will be prompted:

Move all X coordinates by [0.000]

Move all Y coordinates by [0.000]

Move all Z coordinates by [0.000]

Enter the desired figures and go back to screen lines to view the changes.

Stretch/Shrink

AutoBoat/Yacht/Ship has the very powerful abiity to rescale a "parent hull" independently in all 3 dimensions. By using ***Stretch/Shrink***, one can design a family of boats sharing the same characteristics, curve of areas, prismatic and other coefficients.

For example, on a parent hull, by changing the multipliers to X=1.2, Y=1.1 and Z=1.05 you can make the boat 20% longer, 10% wider in beam and a 5% increase in height.

Another use of the multipliers is to change units. For exaple, if you have designed a vessel in feet, but the client wants offsets and hydrostatics in metric, just change the multipliers to .3048. This will result in all dimensions in meters. Going the other way (rep in meters, convert to feet) use 3.28.

Note: Stretch/Shrink multiplies not only the master curves, but the X position of Station 0 and the station spacing. The transom X position and radius is changed as well, but not the angle of the transom. For these changes to become permanent you must SAVE REP. Save under a different file name if you wish to preserve the original hull.

***Stretch/Shrink* (continued)**

You will be prompted:

X multiplier = [1.000]

Y multiplier = [1.000]

Z multiplier = [1.000]

Enter the desired multipliers and go back to screen lines to view the changes.

Reduce by

In lofting, it is often necessary to reduce the hull size by the amount of skin thickness. This routine reduces the hull size by a given amount, normal to the surface. This gives the lines plan the true shape of the inside of the vessel and can be used eithr for lofting or to produce a lines planar to the inside of the skin (and frames) for designing an interior arrangement. Do not use it to reduce the rep by more than a reasonable skin thickness or strange results may occur.

You will be prompted:

```
Reduce normal to surface by [0.000]
```

Enter the desired reduction. None of these changes are permanent until you do a SAVE REP.

NOT SUPPORTED BY AutoBoat.

Trim By

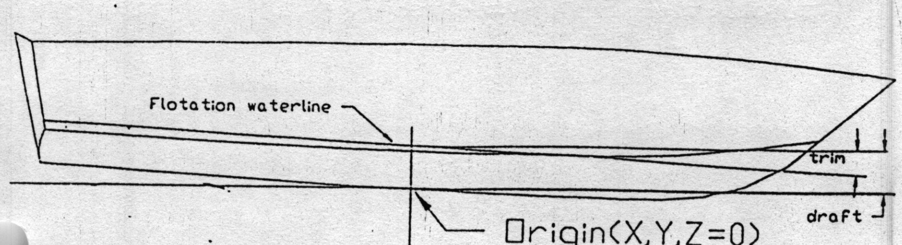
Retrims the lines plan by rotating the master curves in profile, XZ plane. May be used to produce a lines plan "as she floats". The maximum rotation is 10 degrees. The purpose of this feature is to allow small trim adjustments after the lines plan has been completed and faired. The program will refuse to accept any angle greater than 10 degrees.

You will be prompted:

Trim angle in degrees (+bow/ - stern) = [0.00]

The vessel always rotates by the origin, i.e. = x=0, Z=0.
+ angle means down by the bow.
- angle means down by the stern.

Meaning of Draft and Trim



Attach PNL Files

It is possible to attach a PNL file to a hull which will then be displayed in screen lines and also may be shown in the Longitudinal Spline Routine. There are a variety of possibilities for this feature, among them, the ability to show rudder and keel along with the hull by creating a PNL file of keel and rudder with Nacafin or Superfoil. This program allows up to 8 PNL files and allows simultaneous display these files (produced by AutoYacht, AutoSHIP, Superfoil, Nacafin or Auto3D). For an example of the effect, load the rep 12METER which has keel and rudder attached.

You will be prompted:

> Number of PNL Files to attach [2]

Note: You may attach up to 8 PNL files for display with the current hull.

> Drive or Directory to search [\gen4\]?

Screen Lines

Screen Lines
Surf. Normal Curvature
Gaussian Curvature

Screen Lines allows drawing the hull on the high resolution graphics screen of your PC; shows the complete lines plan on screen. The selection of buttocks, waterlines and stations will be the same as set in the SETTINGS menu.

Upon selection of Screen Lines, the following will appear on screen:

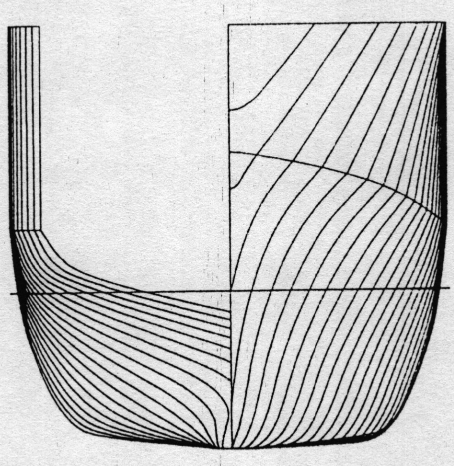
Projection:
(1) Body (2) Plan (3) Profile (4) Axonometric (5) All?

Screen Lines

(1) Body

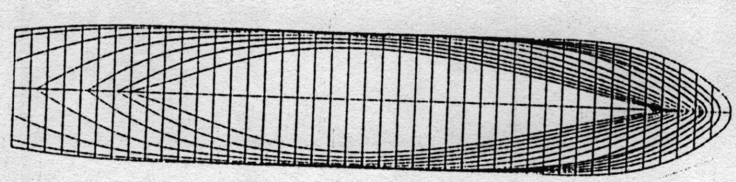
The body plan is drawn in the conventional manner with the bow on the right side and the stern to the left.

In the Body view, the curves represent stations, horizontal lines represent waterlines, and the vertical lines represent buttocks.



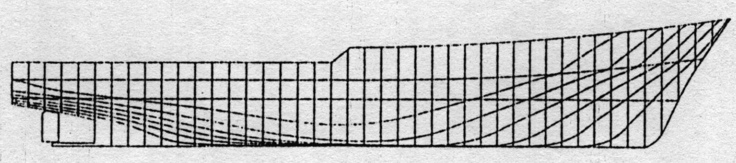
(2) Plan - draws the plan view.

In the Plan view, the curves represent waterlines, the vertical lines represent stations, and the horizontal lines represent buttocks.



(3) **Profile** - draws the profile view.

In the Profile view, the curves represent buttocks, the vertical lines represent stations, and the horizontal lines represent waterlines.

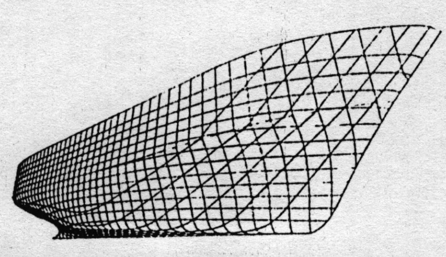


(4) Axonometric - 3D views which allows rotation in the amount of tilt and rotate.

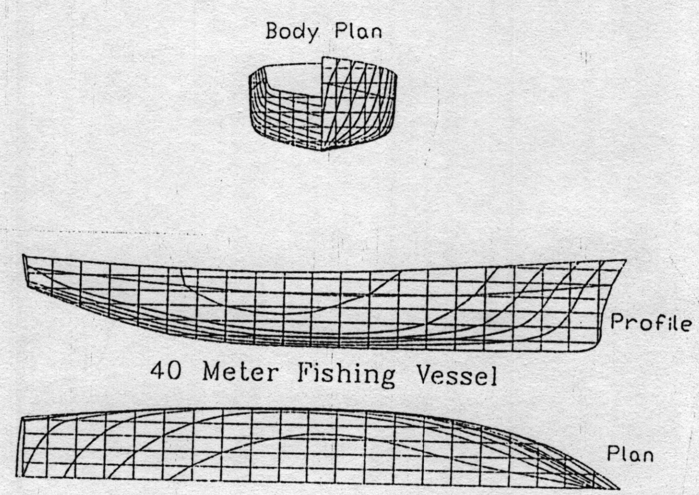
A prompt appears on the upper left corner showing the angle of tilt and rotate in degrees.

Tilt = 15   Rotate = 30

Edit routine in the Axonometric view:
F1 zooms in
F2 restores the full screen view
F5 increases tilt upward by 5 degrees with each push on the function key.
F6 increases tilt down by 5 degrees with each push on this function key.
F7 rotates clockwise in increments of 10 degrees
F8 rotates counterclockwise in increments of 10.
There is no need to wait for view to finish generating. You can hit the function key again as many times as needed to reach the desired view.
Arrow keys UDLR (up, down, left, right) move the hull around the screen.
Pressing the **B** key shows both sides of the hull, Hitting it the second time (toggle) will turn this routine off.
<ESC> returns to the main menu.



(5) **All** - Choosing all allows the lines of the hull in body, plan and profile views drawn at the largest scale that will fit on the screen.



Surface Normal Curvature

Surface Normal Curvature - a test for fairness. Here is what normal curvature means. Imagine you're a bug crawling along one of the longitudinal lines (t=constant) on the surface. Gravity doesn't bother you; as far as you're concerned, "down" is perpendicular to the surface, wherever you happen to be. Normal curvature measures how much the road ahead is curving downwards over the crest of a hill (convex surface; positive normal curvature) or curving upwards in a hollow (concave surface; negative normal curvature). Curves to the right or left have nothing to do with normal curvature; they are ignored.

Just a single curve, to be fair, has to have a continuous distribution of curvature, fairness of a ship hull requires a continuous distribution of normal curvature along each longitudinal. A flat spot shows up as a region of low curvature, a bump as a region of high curvature. Checking the normal curvature along a series of longitudinals is a test of fairness that is far more sensitive than looking at the lines by eye, especially with the limitations of raster graphics.

The screen display shows each longitudinal in turn along with a graph on the bottom of the screen which displays the normal curvature. The baseline is yellow, and the curve is colored coded. The graph on display refers to the last longitudinal drawn.

Surface Normal Curvature (... continued)

The colors are:

> 0 curvature = white
> increasing curvature in the positive (+) direction
> = warm colors (red)
> increasing curvature in the negative (-) direction
> = cold colors (blue)

The graph is also colored to show you the meaning of the surface colors. After you have gone through all the longitudinals, a colored contour map is left on screen until you hit the <escape> key.

Gaussian Curvature

Gaussian curvature could also be called "Compound" or double curvature. Zero Gaussian curvature means that a surface is either flat or curves only in one direction. This is NOT a measure of fairness. For example, a corrugated iron roof has zero Gaussian curvature, but few would consider it a "fair" surface. What Gaussian curvature does show is the "Buildability" of the hull, assuming the vessel is to be plated with metal. Areas of low Gaussian curvature display in white, and then longitudinals are colored toward the red end for positive and the blue end for negative. Therefore the white areas are devopable, or nearly so, while areas of high curvature (bright red or bright blue) are highly curved and require considerable distortion of sheet material in order to conform.

The Gaussian curvature is displayed in graph form on the bottom of the screen. Meaning of the curve is similar to Normal curvature. This routine is new and we frankly do not know how useful it will prove! Let us know what you think.

NOT SUPPORTED

CALC

Upon selection of the CALC Menu, you will be prompted with a sub-menu:

Hydrostatics
Offset Table

Hydrostatics

Hydrostatics calculates volume, displacement, wetted surface, LCB, LCF, Cb, Cp, Cwp, and many other parameters including GM at a given VCG, waterline, and trim. Sink, trim and type of water may be set in the Settings menu. After the parameters are displayed press <enter> to show the curve of areas.

You will be prompted:

> [No] Direct Text Output to Disk Y/N?

> [No] Print Output

Here is a sample printout from the ***Hydrostatic Characteristics*** table of a sample hull named **Demo Hull.**

Hydrostatic Characteristics

SETTINGS		DIMENSIONS	
Sinkage	0.00 ft	LOA	30.52 ft
Trim	0.00 deg	LWL	27.48 ft
Heel	0.00 deg	Bmax	9.57 ft
VCG	0.30 ft	BWL	9.31 ft
Water	Salt	Dmax	-1.86 ft
COEFFICIENTS		Volume	192.46 ft3
Prismatic	0.555	Displ.	5.50 tons
Block	0.403		
Waterplane	0.691	MOMENTS	
Midships	0.726	Trim 1 in.	0.6
RATIOS		Trim 1 deg.	3.3
L/B Ratio	2.95	Heel 1 in.	0.2
D/L ratio	265	Heel 1 deg.	0.4
Tons/In.	0.4	AREAS	
CENTROIDS		Waterplane	177.12 ft2
LCB	15.91 ft (51.9% aft)	Wetted Surf	206.33 ft2
LCF	17.11 ft (56.2% aft)		
VCB	-0.64 ft	STABILITY	
XWS	16.51 ft (54.0% aft)	GM trans	3.95 ft
ZWS	-1.00	GM long	34.61 ft

demo hull

Hydrostatics

How the calculations operate
The upright hydrostatics and wetted area calculations operate on the offset table stored in memory, so the current table is reviewed on the screen and the opportunity given to change it. Since the integrations of areas, volumes, etc. are calculated by the trapezoidal rule, the result will depend somewhat on the particular selection of stations used and the t-spacing. We suggest using at least 11 stations (0-10) evenly spaced along the waterline, and no less than 10 segments for accuracy on the order of 2%. 21 stations and 20 segments gives better than 0.5% accuracy.

Stored with the rep is a variable which tells whether the vessel is metric or feet. If the metric system is chosen, the salt water specific weight of 1025 kg/m3 is assumed and displacement will be in kilos, stabilities in kg.m./degree. Otherwise the program assume salt water weight of 64 lb. per cubic foot and displacement will be in pounds, stability in ft. lb./degree.

In order to calculate initial stability, the vertical C.G. is required. This is entered in the same system as the hull offsets, not in relation to the sunk and trimmed waterplane. If a weight study has not been undertaken we suggest taking the default value of zero, which is usually very close to right on sailboats; metacentric heights and stabilities can easily be corrected later when a VCG estimate is available, by the formula:RM/DEG=-Zcg x Displ/57.3

Hydrostatics

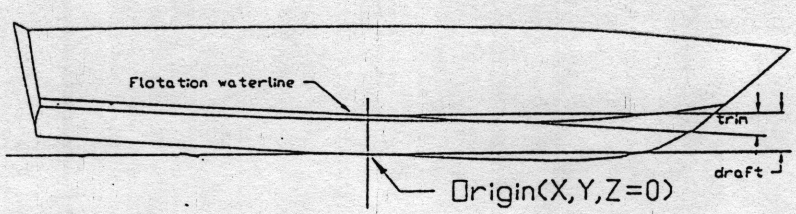
Default values
Default values SINKAGE=0, TRIM=0, put the waterline on the plane Z=0.

Hydrostatics Settings
By going to the **Settings** sub-menu under the **Hydrostatics** Menu, one can specify the attitude of the hull with relation to the waterplane. Picture positioning the hull by making two moves:

1. First, a vertical translation whole boat in the amount of DRAFT (positive downward, negative upward). The units are the same as those in the REP.
2. A rotation about a horizontal transverse axis through the origin of coordinates, by the angle TRIM (in degrees) -- positive for stern upward, negative for stern down.

Meaning of Draft and Trim

FIGURE 4.7



Hydrostatics

Glossary of Terms

LCB Longitudinal center of buoyancy, x position (Sta. no.)

LCF Longitudinal center of flotation x position (Sta. no.)

VCB Vertical center of buoyancy, below the inclined water plane, not the plane Z=0

WS Wetted Surface

XWS Centroid of wetted surface in X-direction

ZWS Centroid of wetted surface in Z-direction

Note: The XWS and ZWS are useful in obtaining weight and CG estimates for the hull skin and structure. A useful attitude to run through the hydrostatics routine is complete submergence; make RISE negative and greater than the maximum freeboard. This obtains the total volume of the enclosed hull, and the total skin area of the hull. The section areas displayed are useful for estimating bulkhead weights and the girths may be used for frame lengths or IOR rating calculations. Note that the transom and deck areas are excluded from the wetted surface calculation even when these areas are under water. In calculating areas for the submerged sections the program assumes a deck level at the height of t=0. The Hydrostatics routine takes only a few seconds so do not hesitate to run it again if you change the REP even slightly.

Glossary of Terms (continued)

LOA Length overall

LWL Length waterline

BWL Beam at the flotation waterline

Bmax Maximum beam or width of boat measured

Dmax Maximum depth of the canoe body of the hull below the specified waterline

Displ. Displacement, weight units

GM metacentric heights in feet or meters given by both transverse or longitudinal directions

WPA Water plane area

PPI Pounds per inch immersion (replaced by KG/cm in metric mode)

RM/DEG righting moment per degree

Cp Prismatic coefficient

Cb Block coefficient

Cwp Waterplane coefficient

Glossary of terms (continued)

Total
Depth Depth from the highest point of sheer right to the deepest point in the bilge.

D/L Ratio
Displacement length calculation by the formula

$$\frac{\text{Displacement in long tons}}{(\text{LWL} \times .01)3}$$

(Even if the vessel is metric, the waterline will be calculated as if it were in feet. This allows comparison of D/L ratios between vessels designed in different units)

Offset Table

Making this selection will generate a complete table of offsets on a station by station basis. In other words, there will be one page of offsets for each station selected in the station table. The buttocks, waterline and other planes output will agree exactly with the curve sequence selected and displayed on screen. At the beginning of the offset table, you will be prompted for a choice of output to text or printer. If neither one is selected, then the output will be to the screen. In order to obtain the most accurate offsets, you should set number of segments at the maximum and resolution at high. See Settings menu.

You will be prompted:

[No] Direct Text Output to Disk Y/N?

[No] Print Output

SETTINGS

The Settings menu features the following prompts:

- Rep Settings
- Stations (X)
- Buttocks (Y)
- Waterlines(Z)
- Planes (Thd,c,d)
- Transom On
- Transom Off
- Curve Sequence
- Hydrostatics
- Units
- Target Area Curve ←NOT SUPPORTED

SETTINGS

Rep Settings

Upon selection of this prompt, a window pops up with the following items which may be set by using the arrow keys and typing new numbers.

X-position of station 0	[0.000]
Station Spacing	[0]
Number of segments (1-100)	[0]
Deck camber in percent (0-50)	[0]
B-spline order (1/2/3)	[2]
Bow rounding code (0/1/2)	[1]
Stern rounding code (0/1/2)	[0]
End condition code	[0]
Straight Line Clamping	[NO]
High Resolution	[YES]

A brief description of each of the above selection can be found under the Files Section.

Stations

Displays the list of stations followed by their X-positions. If no stations have been selected, a dialog box will appear and you will be prompted for first, last, and step.

First	Last	Step
[0.000]	[0.000]	[0.000]

Be sure that your station selection includes the bow and the stern. For example, a typical boat might have a first station of -1, a last station of 11, and a step of .5.

In the edit routine:
<INS> inserts a station
<Del> deletes a station
F1 inserts a group. Don't worry about overlaps, the program sorts and removes duplicates.
F2 key for manual sort/remove, but it takes place any way when you edit.
<TAB> key to switch columns.

Buttocks

A selection of buttocks by Y-position to display on screen.

```
Buttock 1        Y=0.000
```

Buttock 0 is centerline. Editing works just like the edit routine under Stations.

In the edit routine:

<INS> inserts a station
<Del> deletes a station
F1 inserts a group. Don't worry about overlaps, the program sorts and removes duplicates.
F2 key for manual sort/remove, but it takes place any way when you edit.
<TAB> key to switch columns.

SETTINGS

Waterlines

A selection of waterlines by Z-position to display on screen. Editing just like stations.

```
Waterline 1     Z = 0.000
```

In the edit routine:

- **<INS>** inserts a station
- **<Del>** deletes a station
- **F1** inserts a group. Don't worry about overlaps, the program sorts and removes duplicates.
- **F2** key for manual sort/remove, but it takes place any way when you edit.
- **<TAB>** key to switch columns.

SETTINGS

Planes (Thd, c, d)

This selection prompts you to choose the three parameters THETA, C and D in the standard equation for a cutting plane:

z(COS THETA) + y (SIN THETA) = c + dx

THETA is the horizontal angle of the plane in relation to the baseline. THETA of 0 means parallel to the waterline and a theta of 90 would be at right angles to the waterline. WARNING: Height (C) is measured from the intersection of the X, Y, Z=0 points and NORMAL TO THE ANGLE SPECIFIED!!!!

c is the distance the plane is removed from the baseline.

d is the slope of the plane in the fore and aft direction.

For example: 0,0,0 is the Z=0 waterplane.
90,3,0 is the 3 foot buttock.

The main use for this routine is to cut in sheer stripes, boot tops, and the like since other routines take care of buttocks and waterlines.

Upon this selection, the bottom of the screen will show

No planes defined, Insert to add, Escape to abort

Use the insert key if you wish to define a plane and you will be prompted for the Theta, c and d parameters.

Theta = 0, c=0, d =0

Height of Diagonal from WL (X,Y,Z=0) in feet	Height of Diagonal from WL (X,Y,Z=0) in meters	Value to enter for 'THETA' to get the angle as listed below										
		89	87	85	80	75	70	65	60	55	50	45
		Diagonal as measured from Center-line										
		1	3	5	10	15	20	25	30	35	40	45
		Value to enter for 'C' to get the height as listed to the left										
0.250	0.076	0.004	0.013	0.022	0.043	0.065	0.086	0.106	0.125	0.143	0.161	0.177
0.500	0.152	0.009	0.026	0.044	0.087	0.129	0.171	0.211	0.250	0.287	0.321	0.354
0.750	0.229	0.013	0.039	0.065	0.130	0.194	0.257	0.317	0.375	0.430	0.482	0.530
1.000	0.305	0.017	0.052	0.087	0.174	0.259	0.342	0.423	0.500	0.574	0.643	0.707
1.250	0.381	0.022	0.065	0.109	0.217	0.324	0.428	0.528	0.625	0.717	0.803	0.884
1.500	0.457	0.026	0.079	0.131	0.260	0.388	0.513	0.634	0.750	0.860	0.964	1.061
1.750	0.533	0.031	0.092	0.153	0.304	0.453	0.599	0.740	0.875	1.004	1.125	1.237
2.000	0.610	0.035	0.105	0.174	0.347	0.518	0.684	0.845	1.000	1.147	1.286	1.414
2.250	0.686	0.039	0.118	0.196	0.391	0.582	0.770	0.951	1.125	1.291	1.446	1.591
2.500	0.762	0.044	0.131	0.218	0.434	0.647	0.855	1.057	1.250	1.434	1.607	1.768
2.750	0.838	0.048	0.144	0.240	0.478	0.712	0.941	1.162	1.375	1.577	1.768	1.945
3.000	0.914	0.052	0.157	0.261	0.521	0.776	1.026	1.268	1.500	1.721	1.928	2.121
3.250	0.991	0.057	0.170	0.283	0.564	0.841	1.112	1.374	1.625	1.864	2.089	2.298
3.500	1.067	0.061	0.183	0.305	0.608	0.906	1.197	1.479	1.750	2.008	2.250	2.475
3.750	1.143	0.065	0.196	0.327	0.651	0.971	1.283	1.585	1.875	2.151	2.410	2.652
4.000	1.219	0.070	0.209	0.349	0.695	1.035	1.368	1.690	2.000	2.294	2.571	2.828
4.250	1.295	0.074	0.222	0.370	0.738	1.100	1.454	1.796	2.125	2.438	2.732	3.005
4.500	1.372	0.079	0.236	0.392	0.781	1.165	1.539	1.902	2.250	2.581	2.893	3.182
4.750	1.448	0.083	0.249	0.414	0.825	1.229	1.625	2.007	2.375	2.724	3.053	3.359
5.000	1.524	0.087	0.262	0.436	0.868	1.294	1.710	2.113	2.500	2.868	3.214	3.536
5.50	1.676	0.096	0.288	0.479	0.955	1.424	1.881	2.324	2.750	3.155	3.535	3.889
6.00	1.829	0.105	0.314	0.523	1.042	1.553	2.052	2.536	3.000	3.441	3.857	4.243
6.50	1.981	0.113	0.340	0.567	1.129	1.682	2.223	2.747	3.250	3.728	4.178	4.596
7.00	2.134	0.122	0.366	0.610	1.216	1.812	2.394	2.958	3.500	4.015	4.500	4.950
7.50	2.286	0.131	0.393	0.654	1.302	1.941	2.565	3.170	3.750	4.302	4.821	5.303
8.00	2.438	0.140	0.419	0.697	1.389	2.071	2.736	3.381	4.000	4.589	5.142	5.657
8.50	2.591	0.148	0.445	0.741	1.476	2.200	2.907	3.592	4.250	4.875	5.464	6.010
9.00	2.743	0.157	0.471	0.784	1.563	2.329	3.078	3.804	4.500	5.162	5.785	6.364
9.50	2.896	0.166	0.497	0.828	1.650	2.459	3.249	4.015	4.750	5.449	6.106	6.718
10.00	3.048	0.175	0.523	0.872	1.736	2.588	3.420	4.226	5.000	5.736	6.428	7.071
10.50	3.200	0.183	0.550	0.915	1.823	2.718	3.591	4.437	5.250	6.023	6.749	7.425
11.00	3.353	0.192	0.576	0.959	1.910	2.847	3.762	4.649	5.500	6.309	7.071	7.778
11.50	3.505	0.201	0.602	1.002	1.997	2.976	3.933	4.860	5.750	6.596	7.392	8.132
12.00	3.658	0.209	0.628	1.046	2.084	3.106	4.104	5.071	6.000	6.883	7.713	8.485
12.50	3.810	0.218	0.654	1.089	2.171	3.235	4.275	5.283	6.250	7.170	8.035	8.839
13.00	3.962	0.227	0.680	1.133	2.257	3.365	4.446	5.494	6.500	7.456	8.356	9.192
13.50	4.115	0.236	0.707	1.177	2.344	3.494	4.617	5.705	6.750	7.743	8.678	9.546
14.00	4.267	0.244	0.733	1.220	2.431	3.623	4.788	5.917	7.000	8.030	8.999	9.899
14.50	4.420	0.253	0.759	1.264	2.518	3.753	4.959	6.128	7.250	8.317	9.320	10.253
15.00	4.572	0.262	0.785	1.307	2.605	3.882	5.130	6.339	7.500	8.604	9.642	10.607
20.00	6.096	0.349	1.047	1.743	3.473	5.176	6.840	8.452	10.000	11.472	12.856	14.142
25.00	7.620	0.436	1.308	2.179	4.341	6.470	8.551	10.565	12.500	14.339	16.070	17.678
30.00	9.144	0.524	1.570	2.615	5.209	7.765	10.261	12.679	15.000	17.207	19.284	21.213
35.00	10.668	0.611	1.832	3.050	6.078	9.059	11.971	14.792	17.500	20.075	22.498	24.749
40.00	12.192	0.698	2.093	3.486	6.946	10.353	13.681	16.905	20.000	22.943	25.712	28.284
45.00	13,716	0.785	2.355	3.922	7.814	11.647	15.391	19.018	22.500	25.811	28.925	31.820
50.00	15.240	0.873	2.617	4.358	8.682	12.941	17.101	21.131	25.000	28.679	32.139	35.355
55.00	16.764	0.960	2.878	4.794	9.551	14.235	18.811	23.244	27.500	31.547	35.353	38.891
60.00	18.288	1.047	3.140	5.229	10.419	15.529	20.521	25.357	30.000	34.415	38.567	42.426
65.00	19.812	1.134	3.402	5.665	11.287	16.823	22.231	27.470	32.500	37.282	41.781	45.962
70.00	21.336	1.222	3.664	6.101	12.155	18.117	23.941	29.583	35.000	40.150	44.995	49.497
75.00	22.860	1.309	3.925	6.537	13.024	19.411	25.652	31.696	37.500	43.018	48.209	53.033
80.00	24.384	1.396	4.187	6.972	13.892	20.706	27.362	33.809	40.000	45.886	51.423	56.569
85.00	25.908	1.483	4.449	7.408	14.760	22.000	29.072	35.923	42.500	48.754	54.637	60.104
90.00	27.432	1.571	4.710	7.844	15.628	23.294	30.782	38.036	45.000	51.622	57.851	63.640
95.00	28.956	1.658	4.972	8.280	16.497	24.588	32.492	40.149	47.500	54.490	61.065	67.175
100.00	30.480	1.745	5.234	8.716	17.365	25.882	34.202	42.262	50.000	57.358	64.279	70.711
105.00	32.004	1.833	5.495	9.151	18.233	27.176	35.912	44.375	52.500	60.226	67.493	74.246
110.00	33.528	1.920	5.757	9.587	19.101	28.470	37.622	46.488	55.000	63.093	70.707	77.782
115.00	35.052	2.007	6.019	10.023	19.970	29.764	39.332	48.601	57.500	65.961	73.921	81.317
120.00	36.576	2.094	6.280	10.459	20.838	31.058	41.042	50.714	60.000	68.829	77.135	84.853
125.00	38.100	2.182	6.542	10.894	21.706	32.352	42.753	52.827	62.500	71.697	80.348	88.388
130.00	39.624	2.269	6.804	11.330	22.574	33.646	44.463	54.940	65.000	74.565	83.562	91.924

ONLY TEN PLANES ALLOWED!

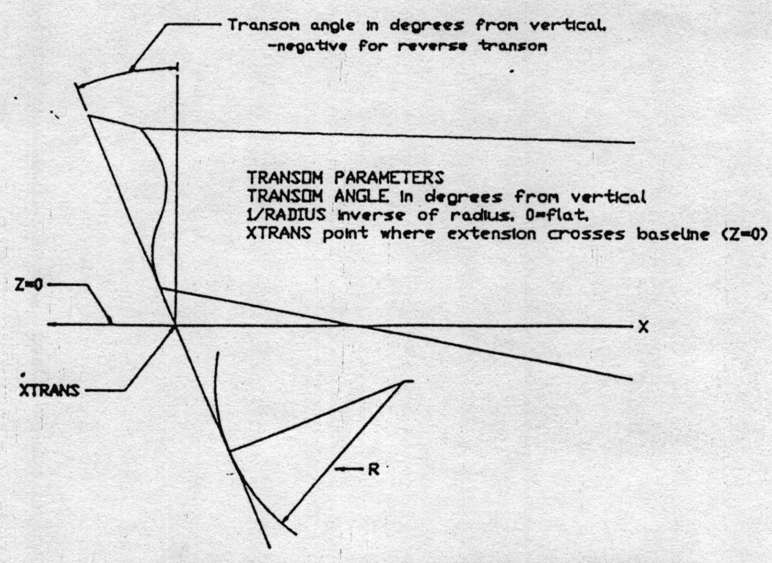
Transom On

You will be prompted for X position where CL of transom crosses the baseline, angle, and radius of transom. Hull lines will be trimmed to the transom edge.

X position where CL crosses Z = 0 [0.000]

Transom Angle (Degrees from Vertical) [0.00]

Transom Radius (0= Flat) [0.000]



PARAMETERS FOR TRANSOM DEFINITION

Transom Off

This selection switches off transom. Hull lines will extend to the last station or the last master curve, whichever is first.

SETTINGS

Curve Sequence

A windows appears with the selection of curves to display on screen.

Sheer/knuckle/Outline	[NO]
Section	[NO]
Waterlines	[NO]
Buttocks	[NO]
Transom	[NO]
Longitudinals	[NO]
Master Curves	[NO]
Rebate Line	[NO]
Trim to Cutline	[NO]
Show Both Sides (iso)	[NO]
Station to switch sides	[6]

Curve Sequence

Yes to the following prompts results in:

Sheer/Knuckle/Outline - Draw sheer and any chines.

Sections - Draw stations.

Waterlines - Draw waterlines.

Buttocks - Draw buttocks.

Transom - Draw transoms.

Longitudinals - Draw all longitudinal splines.

Master Curves - Show all master curves.

Rebate Line - Show bow rounding rabbet. N/A

Trim to Cutline - trim all lines to cutline. N/A

Show Both Sides (iso) - mirror hull.

Station to switch sides - Here you can specify the station number at which body plan switches over.

SETTINGS

Hydrostatics

A windows appears with the hydrostatic settings:

Vertical Center of Gravity	[0.000]
Sinkage (from baseline Z=0)	[0.000]
Trim in degrees (+fore -aft)	[0.000]
Heel in degrees (0 to 90)	[0.000]
Output in tons	[NO]
Show station areas	[YES]
Salt Water	[YES]

a typical set-up is shown above. Edit with arrow keys, spacebar, Yes, No etc. <esc> when satisfied.

Hydrostatics

Vertical Center of Gravity
from weight calculations.

Sinkage (from baseline Z=0)
draft if bottom = 0

Trim in degrees (+ fore - aft)
trims around origin

Heel in degrees (0 to 90)
Not implemented

Output in tons
lbs./kilos or tons

Show station areas
show station area, width, girth

Salt water
Yes to salt water, No switches to fresh water.

SETTINGS

Units

Allows converting a hull from feet to meters and vice-versa. The multiplier will be displayed and may be changed if desired.

Note: All settings are saved with the rep.

SETTINGS

Target Area Curve

Some designers like to match a hull shape to an "ideal" curve of areas. To make this easier, we have provided the ability to display this target curve over the actual curve of areas as displayed in the hydrostatics calculations. The target curve is actually a series of points which you may input on screen. Points are input every 10 percent of the waterline except in the ends where there is an extra point at 5 percent and 95 percent. The target curve is displayed as a series of small boxes which are easily compared with the actual curve of areas of the vessel. Bear in mind that the curve of area displayed is the one at the sink and trim specified. Edit the target curve by inputting the numbers at each location. Use the arrow keys to move up and down and escape to exit the routine. The target curve of areas is saved with the rep so you may stop work on a particular vessel and come back later.

N/A

```
Files   Edit    View    Calc    Settings

 REP STATUS         Target Area Curve in % Max

   X Position         0.00 % at   0 % LWL
   Number of          3.00 % at   5 % LWL     on Spacing         =   2.733
   Bow Roundi         7.50 % at  10 % LWL     ine Order          =   2
   End Condit        15.00 % at  20 % LWL      Rounding Code =   0
   Master Cur        45.00 % at  30 % LWL     ons selected       =  13
                     80.00 % at  40 % LWL     Control Points =   4
                     98.00 % at  50 % LWL
   Transom:         100.00 % at  60 % LWL     rees   Radius =  10.000
                     95.00 % at  70 % LWL
        PNL          80.00 % at  80 % LWL
                     65.40 % at  90 % LWL
                     10.00 % at  95 % LWL
                      0.00 % at 100 % LWL

                   Dimensions in Feet
               AutoYACHT Generation 4
```

N/A

Height of Diagonal from WL (X,Y,Z=0) in feet	Height of Diagonal from WL (X,Y,Z=0) in meters	Diagonal as measured from Center-line										
		1	3	5	10	15	20	25	30	35	40	45
		Value to enter for 'THETA' to get the diagonal above										
		89	87	85	80	75	70	65	60	55	50	45
		Value to enter for 'C' to get the diagonal above										
0.250	0.076	0.250	0.250	0.249	0.246	0.241	0.235	0.227	0.217	0.205	0.192	0.177
0.500	0.152	0.500	0.499	0.498	0.492	0.483	0.470	0.453	0.433	0.410	0.383	0.354
0.750	0.229	0.750	0.749	0.747	0.739	0.724	0.705	0.680	0.650	0.614	0.575	0.530
1.000	0.305	1.000	0.999	0.996	0.985	0.966	0.940	0.906	0.866	0.819	0.766	0.707
1.250	0.381	1.250	1.248	1.245	1.231	1.207	1.175	1.133	1.083	1.024	0.958	0.884
1.500	0.457	1.500	1.498	1.494	1.477	1.449	1.410	1.359	1.299	1.229	1.149	1.061
1.750	0.533	1.750	1.748	1.743	1.723	1.690	1.644	1.586	1.516	1.434	1.341	1.237
2.000	0.610	2.000	1.997	1.992	1.970	1.932	1.879	1.813	1.732	1.638	1.532	1.414
2.250	0.686	2.250	2.247	2.241	2.216	2.173	2.114	2.039	1.949	1.843	1.724	1.591
2.500	0.762	2.500	2.497	2.490	2.462	2.415	2.349	2.266	2.165	2.048	1.915	1.768
2.750	0.838	2.750	2.746	2.740	2.708	2.656	2.584	2.492	2.382	2.253	2.107	1.945
3.000	0.914	3.000	2.996	2.989	2.954	2.898	2.819	2.719	2.598	2.457	2.298	2.121
3.250	0.991	3.250	3.246	3.238	3.201	3.139	3.054	2.946	2.815	2.662	2.490	2.298
3.500	1.067	3.499	3.495	3.487	3.447	3.381	3.289	3.172	3.031	2.867	2.681	2.475
3.750	1.143	3.749	3.745	3.736	3.693	3.622	3.524	3.399	3.248	3.072	2.873	2.652
4.000	1.219	3.999	3.995	3.985	3.939	3.864	3.759	3.625	3.464	3.277	3.064	2.828
4.250	1.295	4.249	4.244	4.234	4.185	4.105	3.994	3.852	3.681	3.481	3.256	3.005
4.500	1.372	4.499	4.494	4.483	4.432	4.347	4.229	4.078	3.897	3.686	3.447	3.182
4.750	1.448	4.749	4.743	4.732	4.678	4.588	4.464	4.305	4.114	3.891	3.639	3.359
5.000	1.524	4.999	4.993	4.981	4.924	4.830	4.698	4.532	4.330	4.096	3.830	3.536
5.50	1.676	5.499	5.492	5.479	5.416	5.313	5.168	4.985	4.763	4.505	4.213	3.889
6.00	1.829	5.999	5.992	5.977	5.909	5.796	5.638	5.438	5.196	4.915	4.596	4.243
6.50	1.981	6.499	6.491	6.475	6.401	6.279	6.108	5.891	5.629	5.324	4.979	4.596
7.00	2.134	6.999	6.990	6.973	6.894	6.761	6.578	6.344	6.062	5.734	5.362	4.950
7.50	2.286	7.499	7.490	7.471	7.386	7.244	7.048	6.797	6.495	6.144	5.745	5.303
8.00	2.438	7.999	7.989	7.970	7.878	7.727	7.518	7.250	6.928	6.553	6.128	5.657
8.50	2.591	8.499	8.488	8.468	8.371	8.210	7.987	7.704	7.361	6.963	6.511	6.010
9.00	2.743	8.999	8.988	8.966	8.863	8.693	8.457	8.157	7.794	7.372	6.894	6.364
9.50	2.896	9.499	9.487	9.464	9.356	9.176	8.927	8.610	8.227	7.782	7.277	6.718
10.00	3.048	9.998	9.986	9.962	9.848	9.659	9.397	9.063	8.660	8.192	7.660	7.071
10.50	3.200	10.498	10.486	10.460	10.340	10.142	9.867	9.516	9.093	8.601	8.043	7.425
11.00	3.353	10.998	10.985	10.958	10.833	10.625	10.337	9.969	9.526	9.011	8.426	7.778
11.50	3.505	11.498	11.484	11.456	11.325	11.108	10.806	10.423	9.959	9.420	8.810	8.132
12.00	3.658	11.998	11.984	11.954	11.818	11.591	11.276	10.876	10.392	9.830	9.193	8.485
12.50	3.810	12.498	12.483	12.452	12.310	12.074	11.746	11.329	10.825	10.239	9.576	8.839
13.00	3.962	12.998	12.982	12.951	12.803	12.557	12.216	11.782	11.258	10.649	9.959	9.192
13.50	4.115	13.498	13.481	13.449	13.295	13.040	12.686	12.235	11.691	11.059	10.342	9.546
14.00	4.267	13.998	13.981	13.947	13.787	13.523	13.156	12.688	12.124	11.468	10.725	9.899
14.50	4.420	14.498	14.480	14.445	14.280	14.006	13.626	13.141	12.557	11.878	11.108	10.253
15.00	4.572	14.998	14.979	14.943	14.772	14.489	14.095	13.595	12.990	12.287	11.491	10.607
20.00	6.096	19.997	19.973	19.924	19.696	19.319	18.794	18.126	17.321	16.383	15.321	14.142
25.00	7.620	24.996	24.966	24.905	24.620	24.148	23.492	22.658	21.651	20.479	19.151	17.678
30.00	9.144	29.995	29.959	29.886	29.544	28.978	28.191	27.189	25.981	24.575	22.981	21.213
35.00	10.668	34.995	34.952	34.867	34.468	33.807	32.889	31.721	30.311	28.670	26.812	24.749
40.00	12.192	39.994	39.945	39.848	39.392	38.637	37.588	36.252	34.641	32.766	30.642	28.284
45.00	13.716	44.993	44.938	44.829	44.316	43.467	42.286	40.784	38.971	36.862	34.472	31.820
50.00	15.240	49.992	49.931	49.810	49.240	48.296	46.985	45.315	43.301	40.958	38.302	35.355
55.00	16.764	54.992	54.925	54.791	54.164	53.126	51.683	49.847	47.631	45.053	42.132	38.891
60.00	18.288	59.991	59.918	59.772	59.088	57.956	56.382	54.378	51.962	49.149	45.963	42.426
65.00	19.812	64.990	64.911	64.753	64.013	62.785	61.080	58.910	56.292	53.245	49.793	45.962
70.00	21.336	69.989	69.904	69.734	68.937	67.615	65.778	63.442	60.622	57.341	53.623	49.497
75.00	22.860	74.989	74.897	74.715	73.861	72.444	70.477	67.973	64.952	61.436	57.453	53.033
80.00	24.384	79.988	79.890	79.696	78.785	77.274	75.175	72.505	69.282	65.532	61.284	56.569
85.00	25.908	84.987	84.884	84.677	83.709	82.104	79.874	77.036	73.612	69.628	65.114	60.104
90.00	27.432	89.986	89.877	89.658	88.633	86.933	84.572	81.568	77.942	73.724	68.944	63.640
95.00	28.956	94.986	94.870	94.638	93.557	91.763	89.271	86.099	82.272	77.819	72.774	67.175
100.00	30.480	99.985	99.863	99.619	98.481	96.593	93.969	90.631	86.603	81.915	76.604	70.711
105.00	32.004	104.984	104.856	104.600	103.405	101.422	98.668	95.162	90.933	86.011	80.435	74.246
110.00	33.528	109.983	109.849	109.581	108.329	106.252	103.366	99.694	95.263	90.107	84.265	77.782
115.00	35.052	114.982	114.842	114.562	113.253	111.081	108.065	104.225	99.593	94.202	88.095	81.317
120.00	36.576	119.982	119.836	119.543	118.177	115.911	112.763	108.757	103.923	98.298	91.925	84.853
125.00	38.100	124.981	124.829	124.524	123.101	120.741	117.462	113.288	108.253	102.394	95.756	88.388
130.00	39.624	129.980	129.822	129.505	128.025	125.570	122.160	117.820	112.583	106.490	99.586	91.924